

INCREDIBLE HISTORY

EVERYTHING YOU NEED TO KNOW ABOUT THE WORLD WE LIVED IN



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Welcome to



BOOK OF

INCREDIBLE HISTORY

History is a fascinating subject, that helps us understand how we reached the point humanity is at now. From the dinosaurs to the Romans, and onto the inventions that paved the way for the technological breakthroughs we take for granted, there's so much about the world we live in that will amaze and astound you. Whether you're trying to brush up on some of the topics covered in the classroom or you're simply intrigued to find out $how the \, Spit fire \, ruled \, the \, skies, \, there 's \, a \, we alth \, of \, information$ packed into these pages. Covering the ancient world, prehistoric times, the iconic buildings and landmarks scattered around the globe, groundbreaking weapons and the inventions that changed the world, there's something for everyone to learn about and enjoy. At the very least, you'll learn some interesting facts that you'll be able to impress your friends and family with! Accompanying all this are some beautiful illustrations and cutaways, allowing you to really see what makes the $things\,covered\,inside\,so\,impressive.$













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HOW IT BOOK OF WORKS INCREDIBLE HISTORY

Ancient History

- **o10** A-Z of the Ancient Greek Olympics
- **014** Greek temples
- o16 Inside a Roman villa
- o18 Roman aqueducts
- **020** How Roman baths worked
- **022** Gladiators
- **026** Mummies unwrapped
- 030 Hieroglyphs
- **032** The Great Sphinx at Giza
- 033 Ancient wells
- o33 Papyrus

😿 Prehistoric

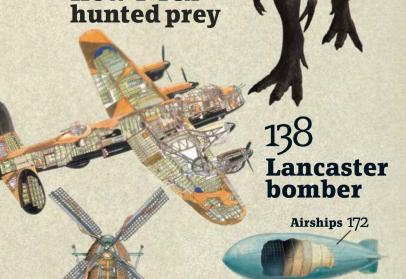
- **036** World's biggest dinosaurs
- 040 Diplodocus
- 042 Triceratops
- **044** How T-rex hunted prey
- 045 Pterosaurs
- 046 Mammoths



Blacksmiths 177

Buildings, Places & Landmarks

- o50 Inside a medieval castle
- 052 Medieval monastery
- 054 Karnak
- 056 St Paul's Cathedral
- 058 Westminster Abbey
- **o6o** Salisbury Cathedral
- **062** Notre Dame
- o64 The Bastille
- **o65** The Eiffel Tower
- o66 Tower Bridge
- **o68** Tudor houses
- **070** The Taj Mahal
- **072** The Great Wall of China
- **073** Leaning Tower of Pisa
- 074 How Venice was built
- 076 Inside the Colosseum
- 078 Pompeii
- 079 Petra
- 080 The White House
- 082 Mount Rushmore
- 083 Statue of Liberty
- **084** Easter Island's statues
- **085** Tutankhamun's tomb
- o86 The South Pole
- o88 Stonehenge
- **089** Shropshire's Iron Bridge
- 089 Big Ben
- 089 Hadrian's Wall



160 How the

Titanic sunk

Medieva

armour

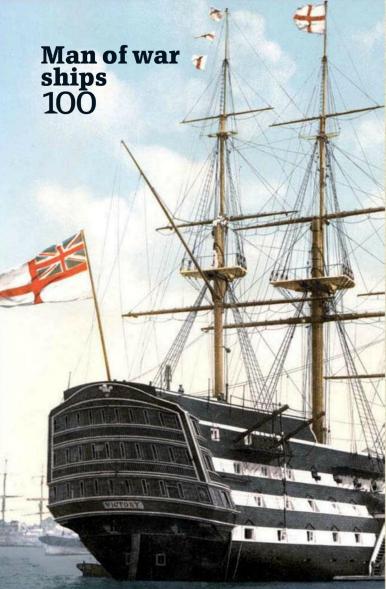
How T-rex

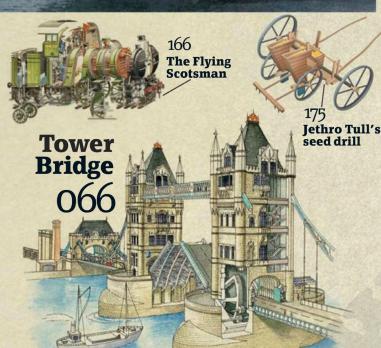
185

Windmills

Leaning Tower

of Pisa





Weapons & War

- 092 Roman forts
- 094 Roman soldier
- 095 Medieval armour
- 096 Samurai armour
- 097 Viking warriors
- 098 Greek warships
- 100 Man of war
- 102 HMS Victory
- 104 Wild west weaponry
- 106 Battle of Hastings
- 110 The Gunpowder Plot
- 112 Siege towers
- 112 The crossbow
- 113 Sword fights
- 113 Naval mines
- 114 Duelling
- 115 Trebuchets
- 116 Gun turrets
- 116 The cannon
- 117 Hill forts
- 118 Attacking a castle
- 120 Mark I tank
- 122 T-34 tank
- 124 The Tiger tank
- 126 Churchill tank
- 128 Willys jeep
- 130 V-1 flying bomb
- 131 Bouncing bomb
- 131 Battering rams
- 132 Battle of Britain
- 136 Spitfire
- 138 Lancaster bomber
- 140 Messerschmitt
- 142 B-17 Flying Fortress
- 144 Avro Vulcan
- 146 Dassault Mirage
- 148 Chariots
- 149 Samurai swords
- 149 The longbow
- 149 Flails
- 149 Pirate cutlass

Greek 01 temples

Industry & Invention

- 152 The age of piracy
- 156 Cutty Sark
- 158 The Mayflower
- 160 The Titanic
- 164 The steam engine
- 166 The Flying Scotsman
- 168 The Mallard
- 170 The Model T
- 172 Airships
- 1/2 Allollips
- 174 The blast furnace174 Chinese earthquake
 - detector
- 175 Jethro Tull's seed drill
- 175 Water pumps
- 176 Early calculators
- 176 The plough
- 176 Self-heating food cans
- 177 Blacksmiths
- 178 Record players
- 180 The first computer
- **181** Typewriters
- 181 Archimedes screw
- 182 Hypocaust
- 182 Roman toilets
- 183 Evolution of the wheel
- 184 Hallmarks
- 184 Fountain pens
- 185 Windmills
- 86 Pendulum clocks
- 186 Zoetropes
- 187 Cuckoo clocks
- 188 Spinning jenny
- 188 Penicillin
- 189 Safety razor
- 190 Thatching
- 191 Electric battery
- 191 Davy lamp
- 191 Tide mills

Talata de



O10 A-Z of the Ancient Greek Olympics

Learn what this historic competition used to involve

O14 Greek temples Take a look inside these multi-use masterpieces

O16 Inside a Roman villa See what made up an ancient Roman home

O18 Roman aqueducts Find out how these structures transported water

O20 How Roman baths worked Not just for bathing, these were places of business

O22 Gladiators Discover how these men fought for survival

026 Mummies unwrapped Uncovering the truth behind Egyptian mummification

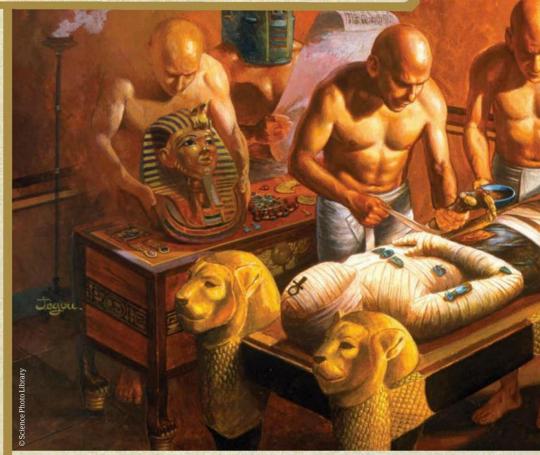
030 **Hieroglyphs**Understanding and decoding this ancient language

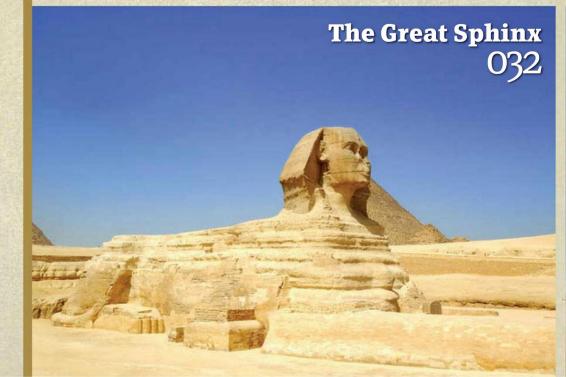
O32 The Great Sphinx at Giza How was this huge stone

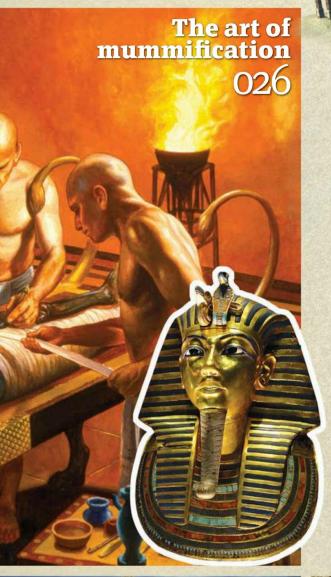
statue built?

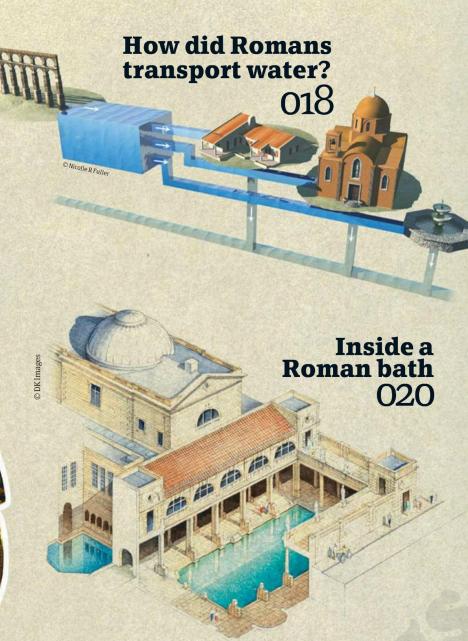
O33 Ancient wells The methods and tools behind raising water

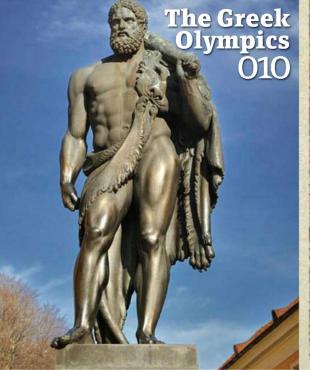
O33 **Papyrus**The early writing material that paved the way for paper

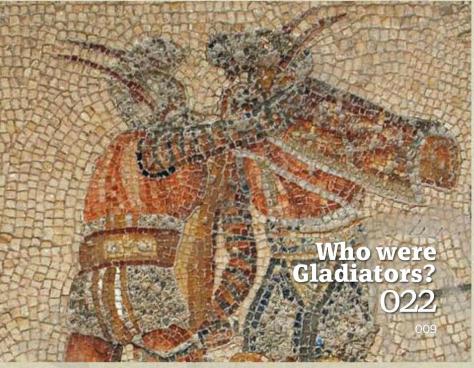
















The modern Olympic Games may certainly look very different to what took place hundreds of years ago, but the underlying ethos hasn't changed in millennia

The ancient heroic code was, as the epic poet Homer put it, 'to strive always to be the best, superior to others'; hence the modern Olympic motto, 'Faster, Higher, Stronger'.

The Ancient Greek world consisted of about 1,500 economically independent city-states, dotted around the coastlines of the Mediterranean and Black Seas, and these states were often at war with one another. Nevertheless, they all thought of themselves as Greeks, and they invented sport, and international festivals such as the Olympic Games, as opportunities to test themselves against their peers without shedding blood – or not too much of it, anyway! The games were even protected by a sacred truce so that competitors and spectators could travel in safety. So, every four years, thousands made their

way to the Peloponnese, the southern peninsula of Greece, where Olympia was situated. Like today, athletes competed for a combination of individual and national glory. The origins of the games are lost in the mists of time: like other games in Ancient Greece, the Olympic festival probably began in celebration of the death of a local hero – perhaps Pelops himself, after whom the Peloponnese is named ('the island of Pelops'). But the Greeks themselves said that the games began in 776 BCE, and took that year as the start of the first Olympiad.

The year 2012 begins the 30th Olympiad of the modern era (since the competition restarted in 1896), but – technically – it begins the 697th Olympiad. The 2012 Olympics recently took place in London, with the 2016 event being held in Rio de Janeiro.

5TOP FACTS

Politics and sport

The unhappy involvement of politics is not only a modern phenomenon. The ancient organisers too sometimes tarnished the Olympic spirit by excluding rival city-states.

The marathon

There was no marathon race in the ancient Games – the story of Pheidippides' run from the Battle of Marathon to Athens in 490 BCE is only a legend.

Winning women?

Women were not allowed to participate in the ancient games, but could be registered as victors – by putting up the money for a winning chariot team.

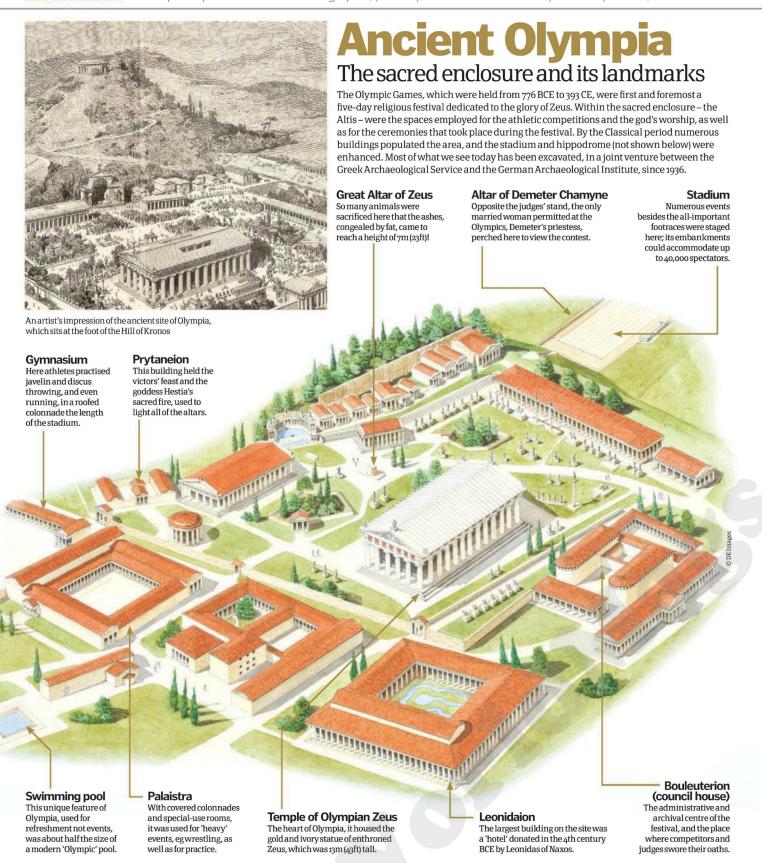
War games

The Summer Olympics were cancelled due to war in 1916, 1940 and 1944, and the same happened in ancient times too. However, these still count for dating reasons.

Pierre de Coubertin

The modern Olympics were the brainchild of Baron Pierre de Coubertin, who felt he was resurrecting the bygone ideal of 'a sound mind in a sound body'.

DIDYOU KNOW? All the participants in the ancient Olympics, for the first several centuries of the competition, were aristocrats





Ancient History

Origins of the Olympic Games

is for... Attis
This is the enclosure, sacred to Zeus, where the Olympic festival took place. For the Olympic Games were a religious festival, not just a sporting event, and the central event of the five-day games was a hecatomb – the enormously lavish sacrifice of 100 oxen at Zeus's altar.



is for... Boxing
Although similar to modern-day boxing, the rules were not quite the same, above all because there were no rounds. Competitors just slugged it out, with their hands wrapped in strips of leather, in a ring formed of spectators, until – maybe hours later – one man was knocked out or collapsed.



is for...

Chariot-racing

Chariot-racing was extremely dangerous, and the wealthy owners trained slaves for all the equestrian events. The two events involving chariots were held in the hippodrome, which was about 600 metres (1,970 feet) long, and wide enough to allow up to 40 chariots to race at one time.

is for... Diet
Ancient athletes recognised the importance of eating special foods for energy and muscle development; they even argued about whether one should abstain from sex while training. An athlete's diet was richer in meat than the normal Greek diet.

is for... **Events**

The only events were those considered suitable training for warfare: boxing, wrestling, pankration (a brutal form of ancient martial art with almost no rules), four running races, the pentathlon, chariotracing and several equestrian events.

is for... Flame

A conspicuous aspect of the modern Olympics is the ceremonial lighting at Olympia of the Olympic flame. This is said to commemorate Prometheus's mythical gift of fire to mankind, but in fact it had no ancient counterpart, and was first introduced for the 1928 Olympics held in Amsterdam.

is for...

Gymnasium

The gymnasium was simply a practice area. The actual events were held outdoors, in the blazing heat of a southern Greek summer, but the Greeks were sensible enough to want to practise indoors. The Olympic gymnasium provided the athletes with all the facilities they needed for both training



is for... **Heracles**

The ultimate strongman, Heracles (who was known as Hercules to the Romans), is credited in one story with founding the Olympic Games. He filled his lungs and sprinted until he needed to draw breath again, and that spot marked the end of the stadium.

Apparently, he could hold his breath for approximately 200 metres (660 feet).

is for... **Inscriptions**The Altis gleamed with statues in bronze and

The Altis gleamed with statues in bronze and marble of famous athletes or dignitaries. But, positioned so that athletes would see them as they entered the stadium, there was also a terrace of statues inscribed with the names of cheats, and put up at their expense as a punishment.



is for... Jugglers

The ancient Olympics were not just an occasion for sport. In a carnival-like atmosphere, poets and orators declaimed, peddlers and prostitutes hawked their wares, and jugglers and other kinds of performers offered entertainment. Spectators mingled in their thousands with contestants and their trainers, slaves and priests, alongside representatives from every walk of life.

is for... Kallipateira

Having no surviving male relatives to train her son, Kallipateira of Rhodes trained him up herself, and defied the strict ban on female presence at the

Olympics by disguising herself as a man. Her deception was discovered, however, when she leapt for joy at her son's success and exposed herself.

is for... **Leni Riefenstahl**

For the Berlin Olympics of 1936 Adolf
Hitler had the filmmaker Leni
Riefenstahl carve the five interlocked Olympic rings
onto a stone, to suggest that this was an ancient
symbol, but in fact it was invented in 1913, to
represent the five main regions of the world.





776 BCE This is the date chosen by Ancient Greek

historians as the start of

the first Olympiad.

Christian Emperor Theodosius I publishes an edict banning the Olympic Games and other pagan practices

Scientific excavation of ancient Olympia begins, under German archaeologist Frnst Curtius (right).



The first modern



allowed to compete in the mes; they are still awaiting

full equality with men.

DID YOU KNOW? The heart of Pierre de Coubertin, founder of the modern Olympics, is buried in a plinth by the ancient site

is for... Milo

Milo of Croton (a Greek city in southern Italy) was perhaps the most famous athlete of the ancient world. He was a



wrestler, and he achieved the astonishing feat of winninginsix successive Olympics, once as a boy and five times as an adult.

is for... **Nudity** For all the track and field events, the male contestants were nude. Penises were tied back against the body with a leather string to minimise discomfort. There were few female spectators, and homoerotic admiration was encouraged by the gratuitous practice of rubbing athletes' bodies with olive oil until they gleamed.

"Cheating was rare: the few events did not readily lend themselves to it, though officials could potentially be bribed"

is for... Oath The spirit of the ancient Olympic oath was exactly the same as its modern counterpart - except that nowadays the oath is not administered over a slice of raw boar meat. Essentially, the athletes swore to play fair, and the judges to judge fairly and not to divulge information about any of the contestants.

is for... **Pentathlon** The pentathlon consisted first of the three events that were peculiar to it: discus, javelin and long jump. If there was no clear champion after the first three events, the contestants were narrowed down by a sprint; if there was still no clear winner, then it was decided by a wrestling match.

is for...

Ouadrennium

The Olympic Games were held, as now, every four years. The other most famous games - at Delphi, Nemea

and Corinth - were four-yearly or two-yearly festivals, and were spaced so as not to clash with the Olympics, and so that athletes could attend a major festival in any given year.

is for... Ribbons

The prizes at the Olympic Games in Ancient Greece were no more than ribbons - bands, intertwined with sprigs of wild olive, to wreathe the heads of the victors. The winner gained enormous prestige, and that was all - though that was sometimes enough to bring him fame and fortune back home, perhaps in the political arena.

is for... Stadium

The sandpit was the venue for wrestling, the hippodrome for equestrian events, and the rest were held in the stadium, whose grassy banks could seat 40,000 spectators. The four footraces were: one- and two-stade sprints, a 20-stade slog and a two-stade race run in armour.



is for... Training

The Ancient Greek lifestyle guaranteed a basic level of fitness, but athletes also practised their specific events and cross-trained through dancing, for instance. All contestants also trained for the month preceding the games in the Olympic gymnasium.

> is for... **Underhand** dealings

Cheating was rare: the few events did not readily lend themselves to it, though officials could potentially be bribed. Despite having a range of medications, the use of performance-enhancing drugs doesn't seem to have been an issue.

is for... Victory The Greeks were not sportsmen in our sense: victory was all, and coming second counted as defeat. Nor were they interested in world records: accurate measurement was difficult, so the focus

was on beating your rivals in the immediate event.

is for...

Women

Except for a single priestess and unmarried girls, women were not allowed into the ancient Olympics. But an all-female festival was organised at Olympia, just before or after the male games. Sacred to Hera, the goddess wife of Zeus, these games consisted of no more than a few footraces.



is for... E'xcellence Competition was a major part of an aristocrat's life - hence the importance of the Olympic Games. Only one's peers counted: Alexander the Great guipped, when asked if he'd enter the sprint, "Only if my opponents are also kings."

is for... Youth

Olympic events fell into three age categories: boys (aged 12-15), youths (16-18) and men (over 18). Success at Olympia could radically change a boy's life. He seemed to be destined for greatness, and back home he would be groomed to play a major part in his city's political life.



is for... **Zeus** Pheidias's 13-metre (43-foot)-high gold-and-ivory statue of the enthroned god, housed in his

temple at Olympia, was one of the Seven Wonders of the Ancient World. Zeus's altar, north of the temple, supposedly marked the spot where he struck the site with his thunderbolt, claiming it as sacred to his worship.



Greek temples

Metopes and triglyphs

Metopes are individual sections

represent the wooden beam of a

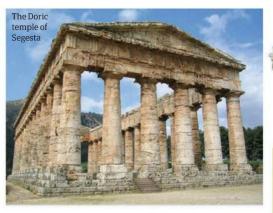
of sculpted stone that show figures of war. Triglyphs may

Inside these multi-use architectural marvels



A temple acted as a cosmic generator. It was regarded as a dwelling designed for the gods and was also seen as a reception area for prayer. magical petition and divination. It also became a political symbol that emphasised the might

and power of the state through ancient architectural achievement. The temple, now the most famous symbol of ancient Greece, was also functional – it housed important official offices and acted as a storage centre and a treasury.





The number of flutes on each column changed with each architectural style.

The Statistics The Parthenon



Length of construction:

Type of building/purpose: Type of architecture:

Ictinos and Callicrates **Area coverage:** 69.5m x 30.9n

Columns

Valued for their beautiful architectural features, columns were also seen as pillars of the sky.

Stereobate or foundation blocks

Foundation blocks were placed at the base of the temple. Doric columns were directly built upon the stereobate.

The ramp

A ceremonial causeway. It leads the individual from the earthly plain and guides him or her to the divine.

Portico

The portico led to an entrance route through which the individual would approach the sacred cult statue.

Head to Head DORIC TEMPLES



1. Temple of Delians Delos, Greece, 478 BC

This temple was founded on the island of Delos – as Delos was the birthplace of Apollo, the temple is dedicated to Apollo and Artemis. This temple was never finished.



2. Temple of Poseidon

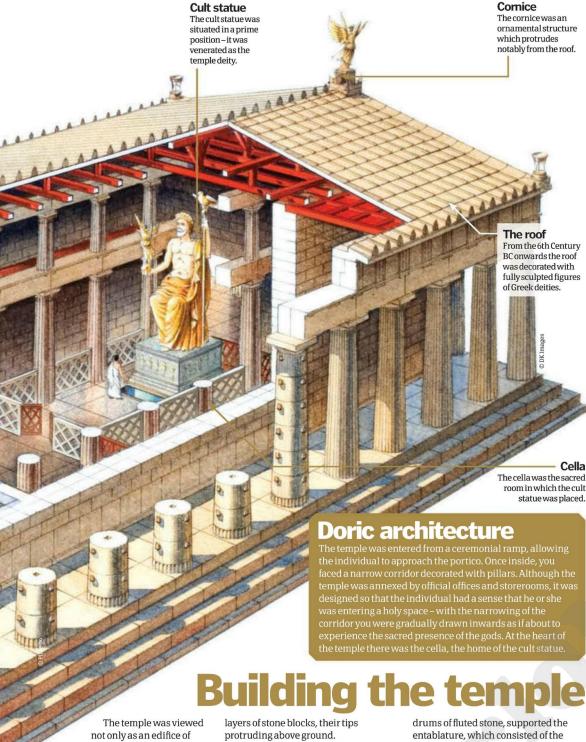
Paestum, Italy, 470-460 BC This temple dedicated to the Goddess Hera was described as "oppressive" by the philosopher Goethe.



3. Temple of Hephaestus Athens, Greece, 447

Athens, Greece, 447 BC
This elaborate temple, which was built on the tip of the Agoraios
Kolonos Hill, was used (until 1834) as a Greek Orthodox church.

DIDYOUKNOW? The Parthenon has been used as an early Christian church and the site of a Turkish mosque



marble, wood and stone, but a magical structure that was designed on astronomical principles. With this in mind, early construction of the temple began with the foundation ceremony, creating a base that is known as a

stereobate. This consisted of several

The workers employed simple tools of bronze and copper. During construction they also used mallets, chisels and ropes to create a further foundation block called a crepidoma, which acted as a base for the columns and walls. The columns, which were made of several

drums of fluted stone, supported the entablature, which consisted of the architrave and the frieze which lay below the cornice. Temple construction could take over a decade, the building often covered 115m x 55m of land and boasted columns that reached 15m to 20m in height. On completion, the temple was decorated by craftsmen.



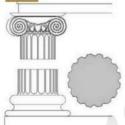
How to identify Greek columns

DORIC



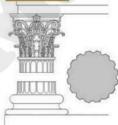
These columns are short, heavy structures with plain capitals. They have no base and their height measures only four to eight times their diameter. The columns are decorated with 20 flutes. The base of the column was placed directly on the stylobate (or the foundation stone), its capital can be seen as a square abacus that connected it to the entablature.

IONIC



lonic columns are graceful and slender – they differ from the Doric in that they are designed with a large base for extra support. They are easily distinguished by their large scrolled features. The lonic column has 24 flutes. The frieze above them is often designed with carved figures.

CORINTHIAN

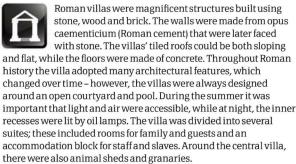


The Corinthian column is ornate and elaborate, and is often more appealing than the Doric and lonic columns described above. The column is tall and slim. Designed with 24 flutes it is crafted with a scrumptious capital, which is sculpted with scrolls and acanthus leaves. The column is often measured at ten metres high.



Inside a Roman villa



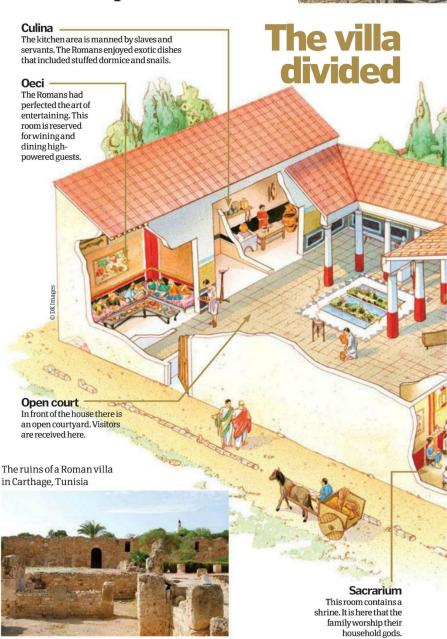


The Roman villa was not simply a house but a symbol of its owner's power and position within society. Therefore, each upper-class Roman sought to impress and intimidate his associates with the building of fine houses constructed within luxurious settings. Within the city walls there was little space, and the Roman villa tended to be small and compact. For this reason the upper classes often took country residences; these houses were used during the hot summer months and were designed as a dwelling for the family, their slaves and estate workers.

The Romans were also interested in agricultural profiteering, so these country villas had landholdings – known as latifundia – and through them, the Roman elite became largely self-supporting, exploiting grain, olive groves and vineyards. They were proud of their self-sufficiency and were able to cultivate fruit and vegetables, as well as keeping fish farms. The Romans also enjoyed ocean-side villas, which provided healthy sea air and brief periods of relaxation before returning to the stress and congestion of city life.

Villas were very much multifunctional residences. As well as being designed to house offices and meeting rooms, they were also used to entertain important guests. They had reception areas, dining rooms, baths and libraries. Like notable English stately homes, they became dynastic symbols of their era.





Restoring Roman mosaics is extremely skilled and time-consuming work

Head to Head ROMAN EXCAVATIONS



Tablinum

The main office used by the

1. Hadrian's Villa, Italy

Dating to the 2nd century AD, this villa, in Tivoli, Italy, revealed important features, including vast underground tunnels and an island retreat.



Atrium

A large square room, it is

2. Aquincum
Located on the outskirts of

Located on the outskirts of Budapest, Aquincum was a vital military base circa 89 AD, which developed into one of the Roman Empire's key cities in central Europe.



3. Villa of the Mysteries

Dated to 79 AD, this Pompeii villa is known for its frescoes that show the initiation of women into ancient mystery cults.

DIDYOUKNOW? In western Europe, deserted Roman villas were often reused for medieval burial sites



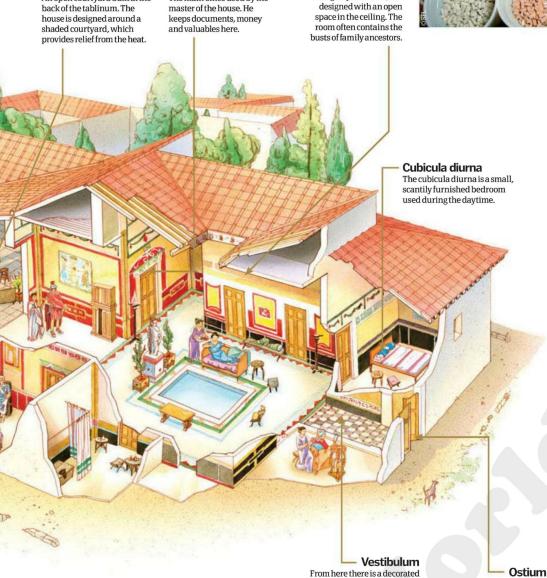
Peristylium

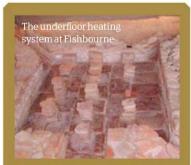
An open courtyard built at the

Making mosaics

Mosaic-making is an ancient art form that was used in eastern traditions long before the birth of the Roman civilisation. However, the Romans perfected the practice using natural materials such as tiles, pebbles and glass. These would be cut into fragments, known as tesserae. They would be placed by a master craftsman on a floor of smooth plaster to create interesting and colourful imagery. The Romans could create vast floors of mosaic that could measure up to ten metres (30 feet) long, often opting for magnificent scenes of wildlife, hunting and gladiatorial contests. From time to time, they also used amusing and even practical images – one villa was designed with a floor of mosaic food; if any morsel were dropped from the table it would go unnoticed.







Fishbourne Roman Palace

Discovered in 1960, Fishbourne
Roman Palace, in West Sussex,
England, had four wings that were
lined with colonnades. It also
featured courtyards, halls and a
bathhouse equipped with underfloor
heating. The Roman palace is thought
to have been built on a larger scale
than the greatest European palaces.
Erected during the 1st century AD, it
was embellished with gardens, pools
and statues. The house was occupied
and extended over several hundred
years – each resident improving the
dwelling and creating beautiful
decorative mosaics, the most famous
being the Dolphin mosaic, which is
located in the north wing. The house
eventually succumbed to fire and was
destroyed in 270 AD, after which it
was abandoned. There are mixed
theories as to the ownership of the
villa, but it may have belonged to
client kings or Roman leaders – one of
whom is thought to be Tiberius
Claudius Catuarus whose ring was
discovered there.

The door is bolted at night and

guarded by a doorman.

pavement that stretches from the door to the street.

Roman aqueducts

The aqueduct was a major component in the Roman water supply. From design to construction, how did these structures transport water across such great distances?

 $\hat{\Pi}$

The Romans placed great importance on sanitation. From 800 BC onwards they established an efficient and complex system that sustained latrines, sewers and drainage

systems. The Romans also built public lavatories where people would socialise, sitting on long benches interspersed with holes. The cities were equipped with fountains that supplied public drinking water. The Romans were also familiar with conservation, and recycled public bath water by flushing it through their latrines. The water was supplied through a network of aqueducts, which acted as arteries throughout Rome; the city was equipped with 11 aqueducts constructed over a period of about 500 years. Aqueducts were also built in other Roman provinces, where they supplied estates, mines and mills.

The management of Roman aqueducts was recorded by a man called Frontinus, who mapped and surveyed these ancient water systems. In the city of Rome, the combined length of the aqueducts is estimated at around 800km (500 miles). As in the case of many aqueducts, only a small proportion – 47 kilometres (29 miles) – could be seen above ground. Most Roman aqueducts ran underground, helping to keep the water free from disease.

In addition to masonry aqueducts, the Romans built an extensive series of leats: these water channels, excavated in the ground, were designed with a lining of clay. This amazing system allowed the steady growth of the city state, and helped to maintain both a military and civilian population.



Long-distance water supply

Water was carried over long distances, winding round unpassable obstacles.

How water was distributed from Roman aqueducts

Basin

The influx basin or header tank contained several chambers and a drainage system, where it collected and stored water.

The venter

An increase in static pressure was found when water passed through a valley. The venter bridge reduced pressure on the siphon.



Head to Head



1. Aqua Appia Dated 312 BC, it flo mostly underground and vas capable of delivering 73,000 cubic metres (2.6 million cubic feet) of ater daily into Rome

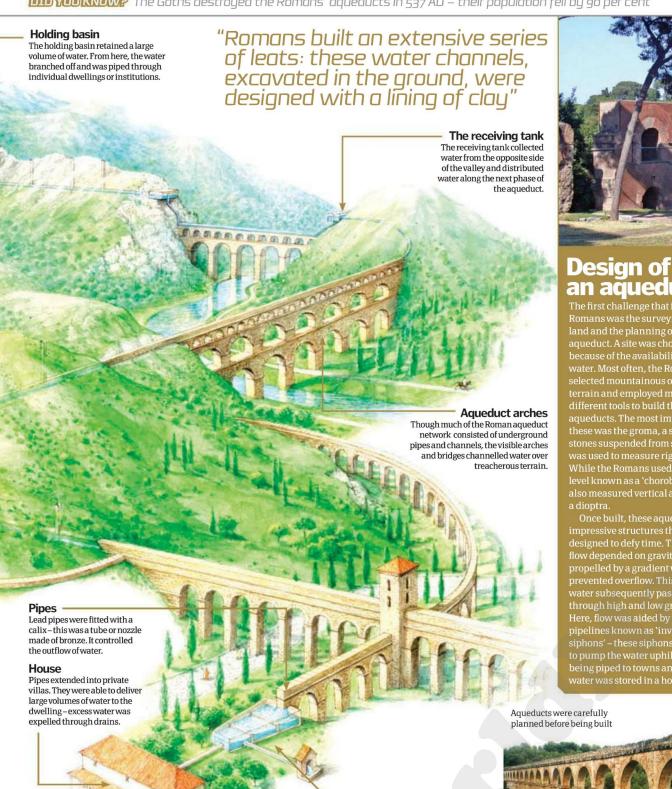


2. Aqua Marcia The longest Roman aqueduct, it was founded in 144 BC. The source for the aqueduct was over 91km (57 miles) away in the Anio Valley.



3. Aqua Traiana Dated June 109 AD, Traiana was designed to supply grain mills. During the 17th Century, it was reconstructed by the Vatican. This map shows its route north-west of Rome.

DIDYOUKNOW? The Goths destroyed the Romans' aqueducts in 537 AD — their population fell by 90 per cent



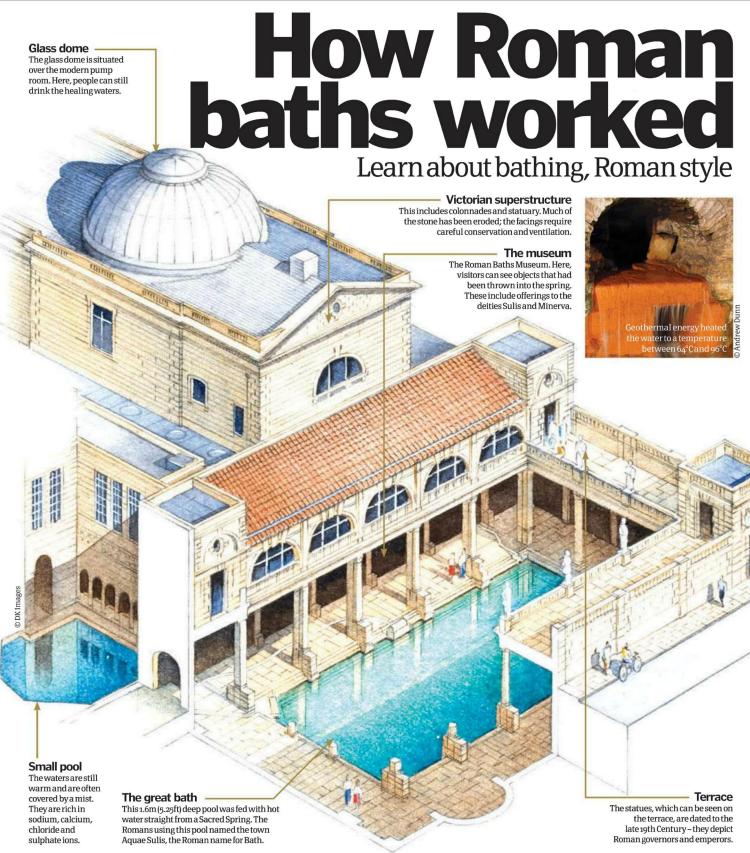
Romans was the surveying of the land and the planning of the aqueduct. A site was chosen terrain and employed many different tools to build the these was the groma, a series of was used to measure right angles. While the Romans used a water level known as a 'chorobate', they

impressive structures that were designed to defy time. The water flow depended on gravity, and was through high and low ground. Here, flow was aided by pressurised pipelines known as 'inverted water was stored in a holding tank.

Gardens

The Romans enjoyed water gardens and ornamental fountains. The gardens were designed with pools and shallow tanks, which continuously circulated water through terracotta pipes.





5 TOP FACTS ROMAN RECREATION

Cleanliness

The Romans were renowned for their personal hygiene. An emperor was once asked why he took a bath every day. He answered: "because I do not have the time to bath twice."

Bathing and politics

The baths were often used in advantageous ways by the Romans. If a politician wanted the favour of the public, he would offer free admission for the day.

Cleaning agents

The Romans did not use soap within their washing routine. Instead, they employed oils to cleanse the body and then used sticks called 'strigils' to scrape the skin.

Healing waters

The Romans believed that the waters they bathed in had special healing properties. They bathed to relieve rheumatism, arthritis and even hangovers.

Fragrant oils

The Romans were particularly fond of massage oils and perfumes. They treasured unguents made from such ingredients as almonds, bergamot and myrtle.

DIDYOUKNOW? Baths were frequented by thieves. Victims crafted 'curse tablets', inscribed with the names of the offenders



The Romans were expert builders; they knew that in order to make their cities thrive they must

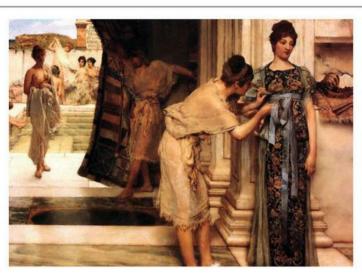
provide an excellent water system. Therefore great importance was placed on drainage, public fountains and baths. Roman baths were built not only in cities, but also in houses and even in forts. The baths were heated in one of two ways.

The favoured method was natural hot springs, with thermae (bath houses) built around them. When the baths were supplied with water from rivers or aqueducts, however, it was heated by a fire before it passed through pipes to the bathing area. Both men and women could use the baths, but the females had to be separated from the males and used an adjoining complex that housed a smaller thermae. The bathing fees for women were much steeper than those required of men.

The bath building was entered through a passage that led into the

room lined with seats and clothes pegs. This room, also known as the 'apodyterium', is where people undressed. Sometimes the visitors were accompanied by servants and slaves who helped them disrobe. The apodyterium was sometimes watched by an attendant. It's unlikely the Romans bathed naked; they were more likely to have worn a light covering known as the 'subligaculum' and sandals with thick soles to protect their feet from the heated floors.

Visitors to a Roman bath could enjoy three types of bath: the hot pool was known as the 'caldarium', the 'tepidarium' was kept at an intermediate temperature and the 'frigidarium' was used as a cold plunge pool. The building also had an atrium, which was employed as an exercise yard. The bath houses were equipped with large public latrines which consisted of marble seats placed over open channels, through which there was a constant flow of water.



Roman baths were frequented by the upper classes, who wished to network and conduct business affairs. While they bathed they were offered refreshments, and at an extra price the visitors could take massages. The treatments were undertaken by slaves known as 'aliptae'. The baths were also used for cultural purposes – they had libraries, eating areas and rooms that were used for public speaking.



The statistics...



Roman baths

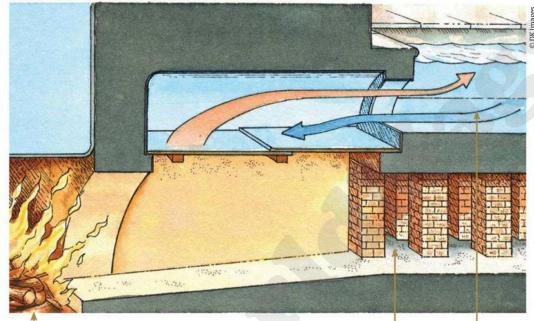
Location: Bath, UK

Years of construction: Constructed in 60-70AD (developed over 300 years)

Type of building/purpose:

Heating Roman baths

If the water was drawn from a river or aqueduct, it was heated by a furnace. A hypocaust system was designed to circulate heat around the building. The hypocaust system was simple but effective – it functioned beneath a raised floor that was supported by a series of plinths. Hot air was then circulated beneath the ground.



The furnace

The furnace was constantly fed with wood. The rooms requiring most heat were situated close to the fire.

The hypocaust

Pillars or plinths created large spaces that were employed for the circulation of heat.

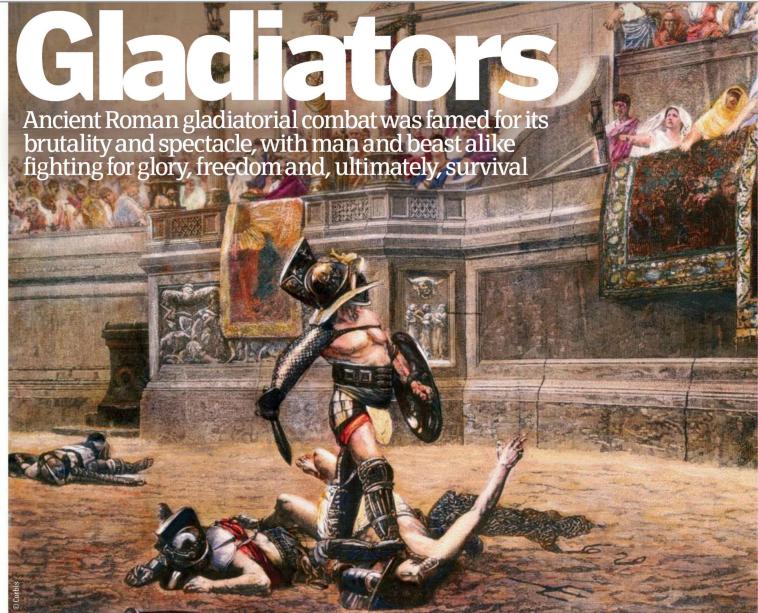
Waters-

There were three types of pool, varying in temperature. They included hot, tepid and cold water.



Ancient History

Life of a gladiator





Throughout the Roman Empire, gladiatorial combat was one of the most watched and celebrated forms of popular entertainment. Men, women

and animals shed each other's blood in a fierce arena where, more often than not, there were only ever two basic choices: to kill or be killed.

Roman gladiatorial combat emerged in the 3rd century BCE in Campania, southern Italy, as part of funeral rites, with combat - simulated or not - put on as part of commemorations. It quickly evolved, growing in both stature and lavishness with increasingly large celebrations. By the 1st Century CE it peaked with the adoption of gladiatorial combat into state-held games - extravagant, month-long celebrations put on for victories, coronations and religious dates. This upscaling in the size of the events led to the creation of dedicated gladiatorial

schools, where slaves, convicts and prisoners were forced to fight.

The gladiator schools were run by a school head (or lanista), who would acquire potential gladiators, then house and train them over a series of months or even years. The school would then either lease or sell gladiators to the state or private families. Nobles often invested in them and were encouraged to as it was seen as an acceptable business for the upper classes. Interestingly, while it was deemed proper for the aristocracy to own gladiators, the heads of gladiatorial schools were perceived as lowly members of society, with most referred to as nothing more than common slavers.

Gladiator training was equally complex. Far from each person solely being trained to fight with a simple sword and shield, in fact individuals were categorised into a number of gladiatorial types, each

differing in arms, apparel, armour, accessories and technique. Indeed, records show that there were over 20 different kinds of gladiator, ranging from retiarius net fighters, through to cestus fist-fighters and on to dimachaerus dual-weapon fighters, among many others. Importantly, specific gladiators were paired against others of their same class, or those from one that complemented them, the latter designed to provide greater entertainment. For example, the smooth-helmeted secutores were often pitted against retiarii as the latter's net generally struggled to capture secutores.

Upon arriving at an arena, gladiators were stored in cells near to or under the playing field. Here they could prepare for their upcoming match, select their weapons (or, if they weren't so fortunate, have them assigned) at an armoury, and then be transported via a walkway or elevator to the arena proper.

5TOP FACTS GLADIATORS Origin

The origin of gladiators and gladiatorial games is heavily linked to ancient Etruscan and Campanian peoples of central Italy, where they were held to celebrate military victories.

Peak

2 Gladiatorial games reached their peak in popularity in the 1st Century BCE to the 2nd Century CE, with vast sums of public and private money spent on festivals.

oll.

Historians Mary Beard and Keith Hopkins estimate, at its peak, there were 400 arenas in the Roman Empire and that 8,000 people and animals died in them a year.

Rewards

4 Some gladiators received other prizes as well as freedom after a victory. For instance, Emperor Nero once granted the African gladiator Spiculus a palace.

Women

While most gladiators were men, women did in small numbers enter the arena. But the Roman people saw female gladiators as novel, rather than skilled and fearsome.

DIDYOUKNOW? Roman Emperors Caligula, Titus, Hadrian and Commodus all fought in gladiatorial arenas



Matches varied in complexity, ranging from straight gladiator-on-gladiator bouts, which could end in death for the loser if so decreed by the crowd/emperor, gladiator-on-animal fights, or historically inspired team fights, where groups of gladiators would attack each other as part of a re-enactment.

Importantly though, gladiatorial games did not simply involve gladiators fighting one another. On the contrary, a vast array of events and activities were held within the arena, ranging from animal hunts to musical recitals, theatrical plays to straight-out executions, state announcements and forays into the arena by the emperor himself.

Here, we take a closer look at gladiators and the life-and-death games they participated in, explaining some of the key people, places and processes that made this pastime so well-loved in the Roman era.

Types of gladiator

How did equipment and weaponry vary between gladiators?

Equite
Horse-mounted
gladiators who
wore scale armour,
were armed with a
round cavalry shield,
lance and short-sword,
and were commonly
pitted against other
equites.

Laquearius
A gladiator
armed primarily
with a big lasso for
snaring opponents.
They also carried a
dagger to finish rivals
off. Fought against
many types.

Murmillo
A class of
gladiator known
for their ornate
helmets, which sported
a stylised fish on the
crest. Murmillones
carried a short-sword
and a tall, oblong
shield. They were
typically paired with
thraex gladiators.

Retiarius
These gladiators
were armed
with a large net and
ornate trident. They
wore a loincloth, thick
belt and large arm
guard on their left side.
Retiarii commonly
fought with
murmillones and
secutores.

Provocator
Provocatores
mirrored
legionary soldiers and,
as such, were the only
type to fight with a
breastplate. They
fought with a
rectangular shield and
short-sword and were
only pitted against
other provocatores.

The gladiatorial emperor

Emperor Commodus called himself the 'Roman Hercules' due to his many forays into the arena

The son of Emperor Marcus Aurelius,
Commodus is remembered today both
for his assassination and his passion
for gladiatorial combat. Records
show Commodus was rarely out of
the gladiatorial arena and was
famed for his love of butchering
wild beasts. This included a
one-day killing spree of 100
lions, a giraffe, three
elephants and even
an ostrich, which he
dispatched himself.
He also fought other
gladiators, to which he

He also fought other gladiators, to which he never lost for two reasons. The first is that any proper gladiator who fought him would always cede victory to the emperor before any killing blow was made, and the

second was due to his love of fighting cripples and the ill. This latter taste saw citizens of Rome who were missing limbs taken to the arena, tied together and then killed by Commodus who pretended they were 'giants'. For each gladiatorial appearance, Commodus charged the city of Rome 1 million sesterces, a figure that strained the economy tremendously. Historians argue it was due to his frequent forays into the arena that he was assassinated so quickly, with the Roman people-and specifically the Senate - finding his

Shield

Shield shape and size varied greatly, with large and small circular, oval, oblong and rectangular variants.
Equites had medium-sized, round cavalry shields, while murmillones had tall, oblong shields.

Gladiator essential kit

activities distasteful

and without honour.

Highlighting the major weapons and armour of a Roman gladiator

Helmet

All but a select few gladiators wore helmets, which ranged from visor types as worn by provocatores, through to the smooth all-in-ones worn by secutores. They were generally highly ornate.

Sword

The majority of gladiators were armed with a gladius (short-sword), as depicted here, however a wide variety of weapons were used including nets, spears, tridents, daggers, lassos and scimitars.

Apparel

Interestingly, it was rare for a gladiator to wear a breastplate, with only provocatores protected this way. Leather padding and scales in partnership with a loincloth and belt were far more common across all types.

Guards

Plated greaves and shin guards were common, with the majority modelled after those worn by Roman legionaries. Thraeces were notable for their twin thigh-high greaves, and mock fighters, the paegniarii, for their lack of them.

023



to quickly introduce or remove props,

animals and gladiators during or

between events. Interestingly, in

Rome's Colosseum there exists

evidence that a major hydraulic

as a flooding mechanism.

lifting system could have been used

to lift scenery into the arena, as well

field, allowing each audience

member a great view of other citizens,

their senators, the emperor and the

could purchase refreshments from a

variety of vendors, some setting up

stalls outside and others patrolling

the inner walkways.

combatants. People in the gallery

Holding pens

A critical area of any arena was its holding pens. These held men and beasts alike – often in adjacent cells – and served as a stark reminder of the social status gladiators were assigned (ie fighting slaves). The holding pens were controlled by a gaoler, who was responsible for their security, transport to the armoury and then into the arena. Due to the pens' close proximity to the arena floor, the noise from combat and the crowd would have been immense.



Emperor/editor

As gladiatorial games evolved into grand state occasions, an editor was put in charge, who acted as a key administrator for their patrons. The editor's role included ensuring there was adequate seating and refreshments for the emperor, consort and senators, as well as adjudicating many of the matches. When the emperor was attending the games, key decisions – such as those over whether a combatant should be killed post-duel – fell to him instead.



Beneath the arena – at least at the Amphitheatrum Flavium – was a host of facilities, including the gladiators' armoury. This was a series of secure rooms where the stadium's stock weapons were held as well as where travelling schools could store their own. The rank and type of gladiator determined the weapons they could use, with low-ranked fighters assigned weapons, while famed or experienced fighters were permitted to choose from a selection.

Chariots

In state games – the most lavish of the gladiatorial games – chariots were sometimes used. Interestingly though, while chariots were used in combat scenarios – indeed, the essedarius type of gladiator always fought with them – they were more commonly called upon for historical re–enactments and flat–out races. A relief sculpture from the 2nd Century CE illustrates that these races could accommodate several chariots completing seven or more laps of the arena against the clock.



What's on?

Although fighting was the main draw, each games came with a packed schedule of events

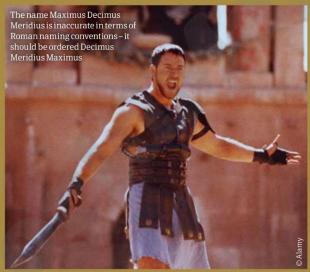
While records indicate personon-person gladiatorial combat was the focus of most of these games, they also show many other events were put on for the crowd's entertainment. These included dramatic re-enactments of past events usually famous battles won by Rome, musical performances, literary readings, animal-onanimal fights, animal parades (usually with exotic creatures), person-on-animal fights and personal performances by the emperor. The exact nature of an event would depend on why it was being held and by whom. Munera - the commemorative events to a deceased ancestor were private, smaller-scale affairs. The state-sponsored ludi games, meanwhile, were much grander in scale, variety and opulence.



Maximus mythbuster

How accurate is the popular Ridley Scott film?

While Gladiator is accurate in some ways – eg in its depiction of gladiatorial schools – it's highly inaccurate in others. First, Emperor Marcus Aurelius died of plague near modern-day Vienna, Austria, rather than being murdered by his son, Commodus. Second, Commodus himself was not killed in the Colosseum, but rather by strangulation in his bathtub. Third, Commodus reigned as emperor for several years prior to his assassination. Fourth, the arena in Rome is referred to by all characters as the Colosseum – as today – but at the time it would have been known as the Amphitheatrum Flavium. Fifth, gladiators in the film are shown fighting others of varying heights, weights and fighting styles, while in reality they were matched up, akin to boxers today. And last, Maximus, the lead character, never existed as depicted in the movie, but is an amalgamation of various historical characters.





MUMMIES

Mummia

1 The term 'mummification' comes from 'mummia', an Arabic word that means pitch or resin. This is a dark viscous liquid that was used during the later stages of mummification.

Ramesses II

Ramesses II was one of Egypt's greatest rulers. When he travelled to Paris for scientific exams, he had his own passport that described him as 'King (deceased)'.

Healing the sick

3 'Mummia' is described by Shakespeare in Romeo and Juliet. Until the 20th Century people took mummia to cure ills such as stomach upsets, headaches and arthritis.

Making a mummy

The artist Robert Lenkiewicz inherited the body of a tramp and mummified the remains. Hotly pursued by Plymouth City Council, he hid the remains in a drawer.

Tutankamun

5 While most mummies are in museums, the remains of Tutankhamun were kept in his tomb. Discovered by Howard Carter in 1922, the body still lies in the Valley of the Kings.

DIDYOUKNOW? In 1975, an organisation known as Summum began to practise ancient Egyptian embalming techniques



packed with herbs, oils and spices, which were known to cleanse and preserve the cavities. If extra body parts were needed the corpse was equipped

and jewellery. Due to heat and lice, the ancient Egyptians shaved their heads, so elaborate wigs (made of human hair) were placed on the deceased. Makeup

"Only the rich could afford to mummify their dead and place them in an elaborate tomb"

with false wooden limbs, or eyes made of obsidian. It was then ready for bandaging. Each limb was carefully tended to; fingers and toes were treated individually, and golden caps were placed on the nails. In order to protect it, a large number of amulets were left on specific parts of the body. Often, garlands of leaves or berries, which were thought to have rejuvenating properties, were placed around the neck. The hair was dressed with oils

was applied, and it was dressed in fine clothes and adornments. While women were buried with combs and pottery, men were armed with daggers or swords. These were placed either on the body or within the wrappings.

At the beginning of the 20th Century, Egyptology was in its infancy. Many early excavators ignored human remains. The first archaeologists were more interested in treasure than mummies, and even the body of

The well-preserved, naturally mummified body of a figure known as the 'Tollund Man

Tutankhamun was subjected to trauma. Although Howard Carter was a brilliant excavator, he could not have imagined the wonders that the dead could reveal. Nor did he envisage that innovations in science would enable us to make important new discoveries about ancient Egyptian mummies. Despite this, the world was now fascinated. Even in Victorian times, the unwrapping of an Egyptian mummy (which often took place in affluent drawing rooms) would be followed by tea, cake and polite conversation.

Thankfully, times have changed and the first scientific unwrapping of a mummy took place in Manchester when Margaret Murray examined the two brothers, Khnum-Nakht and Nekht-Ankh, in 1908. Manchester continues its strong association with the scientific study of mummies. It is here that Professor Rosalie David conducted many innovative investigations into ancient disease. In 1979 she established the International Mummy Database, which employs endoscopy and serological studies, x-ray examinations and MRI scans. Perhaps the most important investigation into ancient mummies was undertaken in Paris between 1976-1977, when the mummy of Ramesses II was met at Orly airport and treated like a visiting head of state. A team of over 100 scientists, including botanists, microbiologists and anthropologists, worked on his body and published startling new evidence

about mummification techniques. Examinations that employ DNA sampling are now used in mummy studies. While the practice is still limited, it can enable Egyptologists to identify, establish and study family groups. We are now able to shed light on the everyday life of the ancient Egyptians, going on to analyse dental hygiene, hair dyes and makeup. When examining mummies we are now able to study textiles, jewellery, oils and even head lice - the oldest 'nits' in the world were found on a Manchester mummy. From these examinations we can learn a great deal about the diseases, afflictions and the general aches and pains of all classes of people, and we can even identify trauma wounds, arthritis and polio.

With the invention of new scanning techniques, the destructive process of 'unwrapping' a mummy is now a thing of the past. What remains constant, however, is that mummies continue to fascinate, excite and inspire us.

1 Ice mummies

Dated to the Pazryk culture, the Ice Maiden and her contemporaries are dated 6th to 3rd Centuries BC. These mummies were buried with elaborate funerary equipment - in the case of the Ice Maiden. there were six

horses and a symbolic last meal. Her body is covered in a series of beautiful blue tattoos which depict mythical animals

2 Mummies of the Canary Islands

The Guanche mummies were found on the Canary Islands in the 15th Century, when they were discovered by Spanish

invaders. Little is known of them - many were pulverised and used as medicinal powders to aid stomach complaints. Dried in the sun, the mummies were packed with sand and wrapped in animal

skins. They were then placed on mummy boards and left in cave

3 Inca mummies Chile, are approximately 500 years old. The remains are those of young children sacrificed on th mountains of the Andes, in order to gods. Other mummies include those known as the 'Cloud People'. in northern Peru.

These mummies were mummified in the driest areas of the jungle.

4 Mummies of the King's Capuchin Catacombs

Dated between the late 16th and 20th Centuries, the mummies of the King's Capuchins Catacombs are magnificent examples of the art of embalming. Thousands of bodies were dried here in

'strainers' (cells that are situated in the passageways of the catacombs). After eight months they were removed and soaked in vinegar. Adults and children are placed on display in coffins, niches and on the walls.



Ancient History

The art of mummification

TYPES OF...

NATURAL MUMMIES

1 Bog bodies
Waterlogged peat holds very little oxygen, and this means that the microorganisms that cause decomposition cannot survive.
The acidity in the bog, along with sphagnum moss, also helps to preserve the body. While the skin, hair and internal organs are remarkably well preserved, the bones are softened. The body begins to take on a dark,



2 Self-mummification
Self-mummification was practised
by the Sokushinbutsu, a group of
Japanese Buddhist monks. For
several years, the monks would live
on a diet of seeds and nuts and
would drink the sap of the Urushi
tree, which would cause vomiting
and loss of body mass. They would
seal themselves in a tomb and die
- if the body had mummified, it was
regarded as a holy vessel.

3 Desiccation
When left in the open, water, insects and heat will rapidly destroy the body. If the body is buried in sand or saft, moisture in the flesh is absorbed and the corpse is preserved. More importantly, in the case of Egyptian mummies the removal of internal organs

4 Ice mummies
Lee prevents decomposition of the
body and inhibits the growth of
bacteria. It also preserves pollen
and dust grains. Ice is an excellent
and effective agent, so ice
mummies seem very lifelike. Their

aids this process, preventing internal bloating and decay.

hair, eyelashes and body
decorations are often
astounding. Ice
mummies have
even been
discovered
with votive
offerings and
grave goods.

Ötzi the Ice Man is a famous natural ice mummy

Death chamber

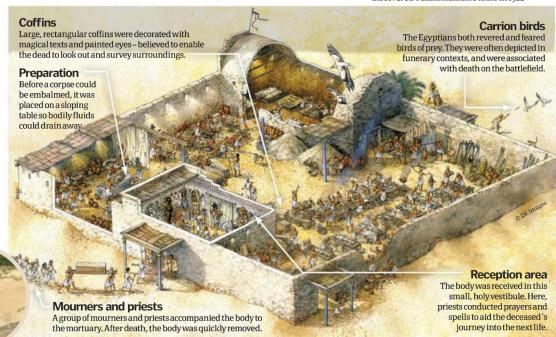
We open the doors to the eerie and mysterious world of the embalming chamber, to explain exactly how the process was performed

Although the House of the Dead was occupied by priests and their servants, it was also regarded as a place of dread. The sight or smell of the embalming chamber was viewed with fear and repulsion. Inside the House of the Dead, there would often be a long queue of bodies waiting to be embalmed; they would be placed on sloping beds so that body fluids and blood would drain into vats. Flies, inexperience and heat could make

the work difficult. As we have explained, the embalming process was an urgent and bloody activity – when rushed, the embalmers often lost or severed limbs. The morality of the morticians was also regarded with suspicion; they were often associated with robbery and corruption. On the other hand, morticians were viewed as mystics and magicians, and a sense of secrecy surrounded their art.



Howard Carter discovered Tutankhamun's tomb in 1922



FROM DEATH TO THE TOMBS



1. The death scene
This bed is a traditional
funeral bier (stand), which

can be found among ancient Egyptian funerary equipment. It was designed to represent the body of a lion.

2. Embalmers at their work

Several priests attended the body of the deceased; while some worked on the body, others would recite prayers and perform magical incantations.

3. Bandaging and anointing

Many metres of linen bandages were used on mummies, where each finger and toe was wrapped individually. The body was anointed in protective oils and resins.

4. Placement in coffin

Coffins differed over the years, both in style and decoration. The coffin was made of wood and gilded with precious metals. It was inscribed with magical texts.

Head to Head MUMMY DISCOVERIES



1. Sir John Franklin In 1847, explorer Sir John Franklin and his crew of 129 disappeared on an expedition to the Arctic. The mummies of Torrington (21), Hartnell (25) and Franklin (61) were found in great condition.



Ice Maiden
Juanita, or the 'Ice Maiden', was sacrificed to mountain deities when she was 13/14 years old.
She was found on a mountain by anthropologist Johan Reinhard.

2. Juana the



3. Tutankhamun's children

Included in the category of rare Egyptian mummies are two foetuses, thought to be the children of Tutankhamun. They are believed to be twins

DID YOU KNOW? Plastination and cryogenics are two more modern methods of preserving the body



A step-by-step look at the mummification process, from deathbed to the grandeur of the tomb



5. Mourners

The coffin was placed on a bier and dragged by oxen to the tomb. It was accompanied by priests, mourners and relatives.

6. Opening — of the mouth

A priest, dressed in leopard skin, would 'open the mouth' of the deceased with an instrument called an Adze. This allowed the spirit to fly free from the body.

7. Placing goods in the tomb

The ancient Egyptians believed that you could indeed 'take it with you'. Their tombs were filled with goods that were needed in the next world.

8. Priest leaving the tomb

At the culmination of the funerary rituals, the priest would leave the tomb. As he retreated, he would sweep away his footsteps from the dust.

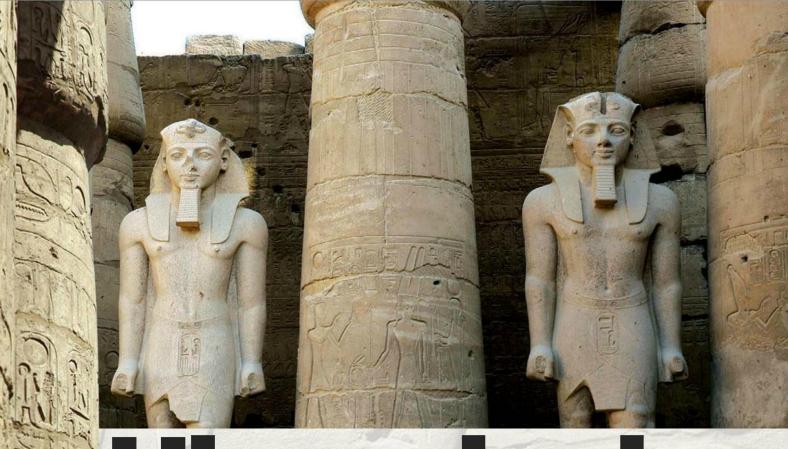
9. Weighing of the heart

The heart is weighed before Osiris, god of the dead. If found wanting, the deceased would be devoured by a crocodile-headed monster.



Ancient History

Hieroglyphs



Hieroglyphs

Understanding the language of the gods



In order to learn the Egyptian script (known in ancient times as medu netcher or `words of the gods`), it is best to start with the alphabet, which is published here in full. As you start to recognise the

words and names in the Egyptian script you begin to understand the excitement and adrenaline that historians must feel when deciphering an ancient text – by doing so, you gain a unique insight into this incredible and mysterious civilisation.

The language is elaborate but also very accessible; it employs a series of grammatical structures that include verbs, nouns, negatives and particles; the Egyptians also used onomatopoeic words, for example `cat` is written `meow.` The language also contains a series of pictograms and phonograms, and is interspersed by determinatives. These are placed at the end of words in order to clarify their meaning.

The script has an abundance of symbols that reflect the natural world; birds, mammals and trees often provide clues to the true meaning of the text. The language could be written left to right, or right to left, and executed vertically or horizontally. The script is continuous and you can learn to separate the words by identifying the determinative or the strokes at the ends of each section.





Ancient scribes

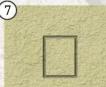
Most Egyptians were illiterate. They employed scribes who would write their letters on rolls of papyrus using reed pens and black ink.

DIDYOUKNOW? The Egyptians wrote poetry, curses, hate mail and fairy tales. They believed words had magical powers



3 (`ahhh`)

Egyptian vulture. This ominous bird is associated with both battlefields and graveyards.



A seat, stool or throne. A sign in ancient Egyptian used frequently in royal titles.



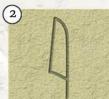


n (emphatic 'h') A twisted piece of flax. Flax was a common material in ancient Egypt.





A reed basket with a handle. This can be used in many contexts and is employed as the pronoun 'you.'



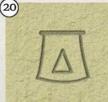
A flowering reed. The reed was used to make arrows and writing tools.



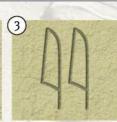
The horned viper is one of many snakes used in ancient Egyptian, it is often attached to a verb.



n (as in hock or lock) The placenta can be found in many words including those that deal with fortune and smell.



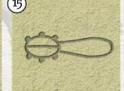
The Egyptians were fond of wine. The sign of this jar stand is transliterated with a hard 'g'.



y (`eee`) Two flowering reeds or strokes that may have represented the sound of the wind on rushes.



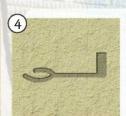
m The owl is a common letter. It is rare to see the full face of any creature in imagery.



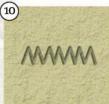
h ('ich') The belly of an animal; this letter is used in words that denote the physical form.



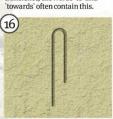
Bread was the most basic food in Egypt, here we see a small loaf of oven-baked bread.



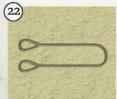
c (e) The arm is often used in the Egyptian language to represent might or power.



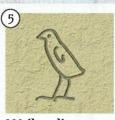
Awater ripple is used to note transience, the words 'to' and 'towards' often contain this.



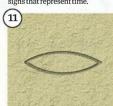
S - 2 symbols A door bolt and a folded sheet of cloth. It sounds like the English 's'. It has several different variations.



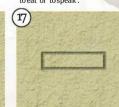
t ('tsh') Tethering rope. The Egyptians had 38 signs for ropes and baskets. 't' is also a pronoun.



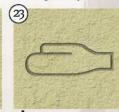
W (`000`) The quail chick adds a pleasant sound. It is often employed among signs that represent time.



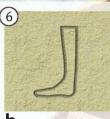
Risshown as a mouth. The letter is used in the words `recitation`, `to eat` or `to speak'.



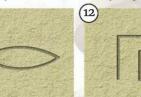
S (`sh`) Water features were a symbol of affluence and upper class villas were designed with pools.



Human hand, There are 63 signs for the human body. This sign was used for words of action.



The foot and leg. Egyptians became familiar with human anatomy through mummification.



There are various 'h' sounds in the alphabet. This sign shows a rural shelter or a house.



K (like 'qu' in quaint) The hill sign is used in the words 'tall,' 'high' and 'exalted' as well as 'high ground' or 'summit'.



d (dj) Snakes were feared creatures. This letter is often used in words of declaration or recitation.

The Rosetta Stone The ultimate ancient code-breaker

The Rosetta Stone is viewed as one of the most remarkable finds of the ancient world. It was discovered in Egypt back in 1799. The stone itself is inscribed with a decree issued on behalf of King Ptolemy V at Memphis in 196 BC. The top and middle sections of the stone are carved with hieroglyphs and demotic - a variation of the Egyptian text. The lower section is decorated with the Greek script which

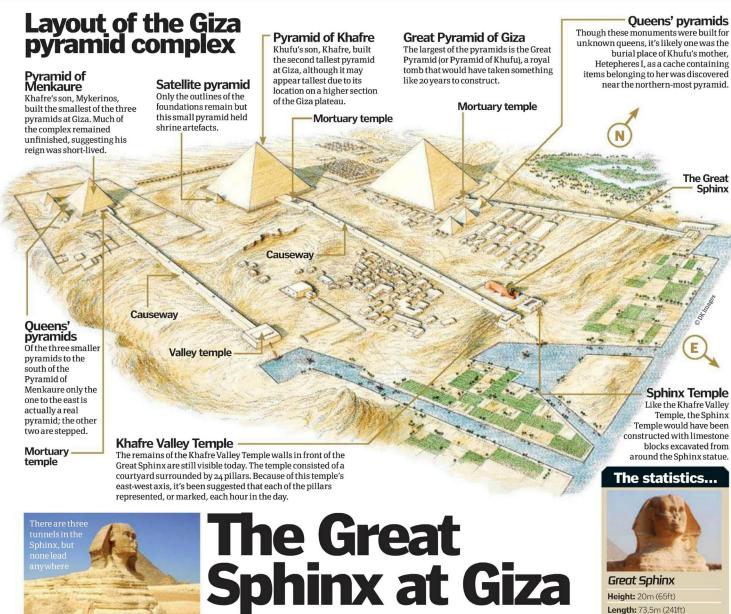
ultimately acted as a code breaker for the upper sections.

A series of scholars were involved in the race to decipher the hieroglyphic code, but ultimately the breakthrough is credited to Frenchman Jean-Francois Champollion (1790-1832). Champollion used the Greek portion of the text to reveal the secret language of the pharaohs.

The missing link The Greek text helped decipher the hieroglyphs









The Great Sphinx is the huge monolithic statue of a human-headed lion that was carved into a single mass of limestone bedrock on the western bank of the Nile

during the third millennium BCE. The Sphinx faces directly east and its stonework features once included a cobra-embellished headdress and a beard.

Though neither the Sphinx nor its principal architect were cited within the content of any hieroglyphs from the time, the 'foreman' of the project is widely regarded to be Pharaoh Khafre (c. 2558-2532 BCE), the ruler of the Old Kingdom, which was a period of early Egyptian civilisation that endured for 2,500 years. Incidentally, Khafre's father - Khufu (c. 2589-2566 BCE) - built the Great Pyramid at Giza

approximately 400 metres (1,300 feet) from where the Sphinx statue would later be carved.

the world's largest single-stone statue

Discover the answers to the mysteries surrounding

Regarding the identity of the labour force, an Old Kingdom cemetery containing the tombs of some 600 possible workers and overseers was unearthed in the early-Nineties. Following that, in 1999 Egyptian archaeologist Mark Lehner found a settlement dating back to the reign of Khafre, capable of accommodating between 1,600 and 2,000 people - a rather convenient Sphinx construction workforce, perhaps?

4,500 years ago, before bronze and iron were prevalent, the available tools for this colossal undertaking would have included copper implements and stone hammers. Modern reconstructions, using similar stone and ancient-style tools, have estimated

that the Sphinx could have been constructed in just three years with 100 people chipping away at a rate of o.o3 cubic metres (one cubic foot) per week.

Height: 20m (65ft) Length: 73.5m (241ft)

Width: 6m (20ft) Build date: c. 2500 BCE

Using the huge excavation of stone quarried away from the Sphinx enclosure (the pit in which the statue sits), the labourers were also able to construct the nearby Sphinx Temple. Each block that was removed from the Sphinx statue site could have weighed up to 200 tons and would have been transported on rollers.

Until the Thirties, when an archaeologist called Selim Hassan excavated the lower half of the statue, the Great Sphinx remained buried up to its shoulders by sand. Today it stands proud alongside the other monuments of Giza as a testament to the engineering skill of the Ancient Egyptian civilisation.

1. Papyrus stems of the papyrus plant, this was uneven, stained if made incorrectly and susceptible to mould and

2. Vellum Traditionally made from mammal skin, vellum was smooth and durable. It involved bleaching, stretching, staining and

1. The well



3. Paper Produced by creating a cellulose pulp derived from wood, rags and grasse before adding chalk and clay and finished with coatings of calcium carbonate.



Before running water, people relied on wells to access water but how was the water raised?



The first form of wells were hand drawn or dug wells, which were constructed through

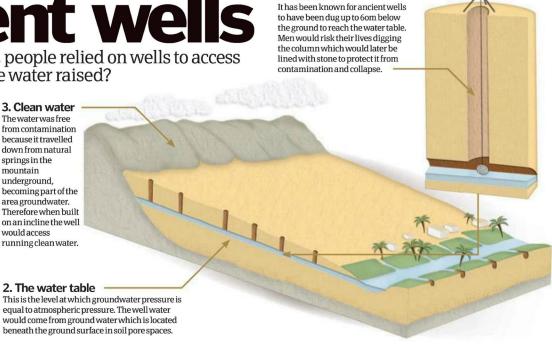
excavation of men digging down through the earth to below the water table. The well wall and outer rim were lined with stones to avoid contamination and reduce the risk of people or animals falling in.

Early wells were pumpless so a pot (pail) attached to a rope was fed to the bottom to collect water and retrieve it. The earliest known wells are from the Neolithic period, with the oldest dating back to 8100-7500 BC. Today wells are created with advanced drilling equipment and feature pumps to draw the water to the surface.

3. Clean water The water was free from contamination because it travelled down from natural springs in the mountain underground. becoming part of the area groundwater. Therefore when built on an incline the well

would access

2. The water table This is the level at which groundwater pressure is equal to atmospheric pressure. The well water would come from ground water which is located beneath the ground surface in soil pore spaces.



Papyrus

An ancient form of writing material derived from the plant of the same name, papyrus was important in the development of paper production



Papyrus paper was made by taking multiple stems from

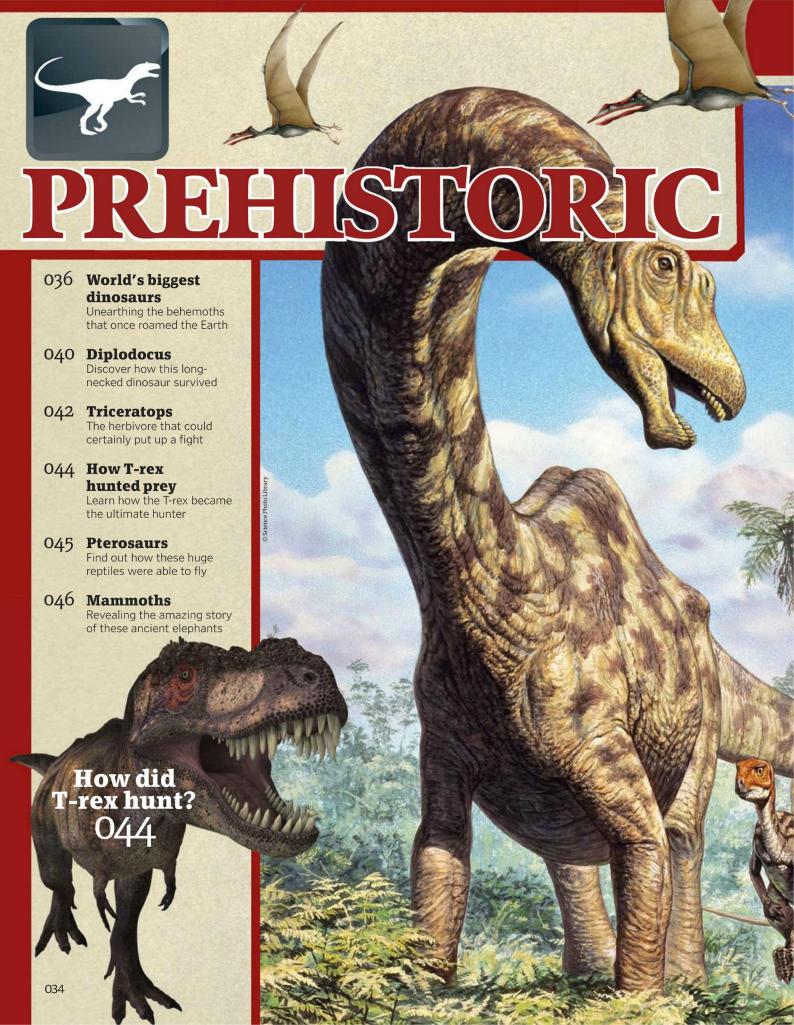
the Cyperus papyrus plant, a grasslike aquatic species with woody triangular stems that grew commonly down the banks of the Nile delta region in Egypt. The fibrous stem layers within are extracted and sliced into thin strips. These strips are laid out in rows topped with another layer of strips arranged at right angles. The layers are then dampened and $pressed\,together\,into\,a\,sheet.\,This$ sheet of pressed strips is then left out in the sun to dry, forcing the plant's sticky, glue-like sap to act as an adhesive and cementing the layers together. Finally, the dried sheet of stems is hammered and pasted together with others to form a roll of paper ready for writing, drawing or even painting.

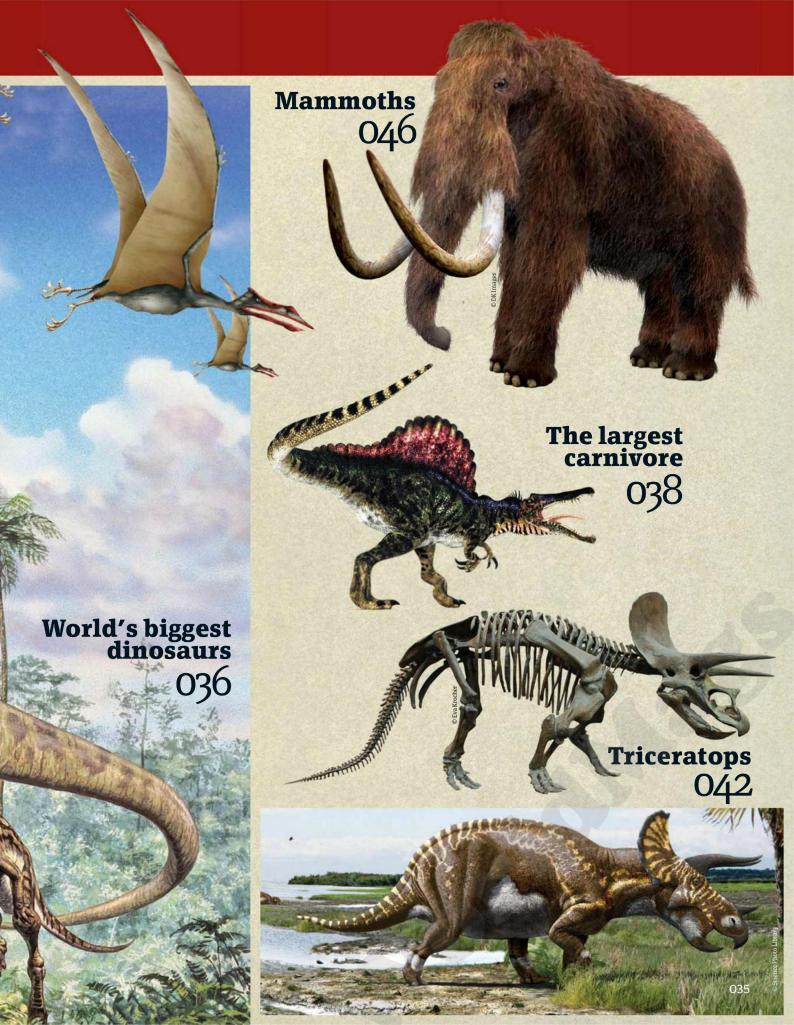
It was the ancient Egyptians (from the third millennium BC) who caused the proliferation of papyrus, due to the sheer quantities of the plant available to them. However, the technique soon spread throughout the Mediterranean and was used commonly by the Greeks. Indeed, many ancient documents emanating from the area are all written on papyrus and examples of its use have been recorded as late as the 12th Century from the Byzantine Empire.

While papyrus in hot climates provided a cheap, stable and largely deteriation-proof writing surface, that was easier to transport over long distances than tablets or animal skins, its tendency to mould in damp conditions and crack if bent led its use to be restricted. Papyrus was

eventually replaced by parchment and vellum, which offered greater durability and a much smoother









5 TOP FACTS SMALLEST DINOSAURS

Microraptor

This tiny raptor, resembling an odd-shaped pigeon, lived in the early cretaceous period. It measured no more than a foot from head to tail and weighed less than a kilogram.

Raptorex

Gracing the Earth 60 million years before T-rex, raptorex is the smallest tyrannosaur discovered so far, weighing less than 154lb (70kg), much less than its famous cousin.

Europasaurus

Sauropods are considered to be extremely large, but the under-a-ton europasaurus was comparable in size to a modern ox, averaging about 3m (10ft) in length.

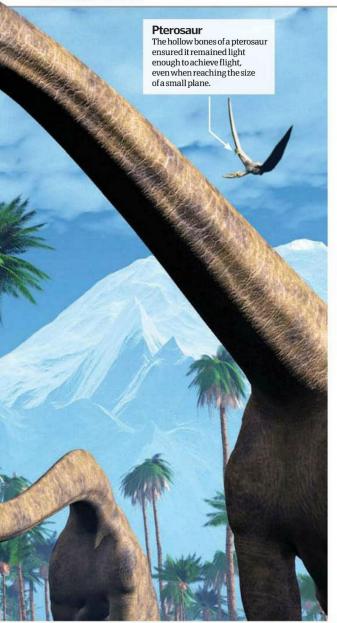
Nemicolopterus

This pterosaur is the smallest known 'flying dinosaur'. It had a wingspan of 25cm (IO") and weighed about 0.lkg (0.2lb). It came about 50 million years before the quetzalcoatlus.

Lariosaurus

Lariosaurus is the smallest marine reptile discovered to date. It was about 0.6m (2ft) long and weighed 9kg, becoming extinct at the end of the Triassic period.

DIDYOUKNOW? The biggest animal ever known to have lived on Earth, including dinosaurs, is the blue whale





It's somewhat frightening to imagine what it must have been like to wander around the plains of Africa and Argentina 100

million years ago. Whereas today you'd be hard-pressed to encounter a beast any bigger than yourself, back then you'd be running for your life as bus-sized creatures roamed free, some remaining largely peaceful and distant, others full of aggression.

The biggest land-based animal alive today is the African bush elephant, with the largest weighing a measly 13.5 tons and measuring 10.6m (34.8ft) long and 4.2m (13.8ft) high. Argentinosaurus, the current official record-holder for largest dinosaur of them all, would have been at least four times the size. It was a sauropod, dinosaurs of the Jurassic and Cretaceous period that were mostly herbivores and known for being very large. Indeed, many other types of sauropod would have stood tall above the African bush elephant, as would carnivores, raptors and pterosaurs ('flying dinosaurs').

Of course, the dinosaurs inhabited the Earth for much longer than any modern animal, from 251 to 65 million years ago, allowing plenty of time for certain species to develop into the giant hulks of flesh we now so revere. The biggest dinosaurs discovered to date have largely been determined to live in the Late Cretaceous period, 99.6-65.5 million years ago, before they faced extinction.

For a long time, though, palaeontologists have wondered why dinosaurs grew to be so large. While impressive, size can also be a hindrance. Not only does a large animal need

a much higher rate of metabolism, but it must also develop much stronger bones and skeletal structures to be able to hold itself upright. Many of these gigantic animals were also cumbersome and slow, leaving themselves open to attack from large predators. Why did dinosaurs continue to grow for millions of years, then?

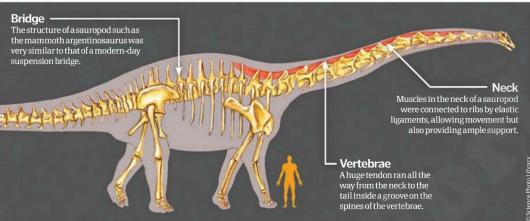
One train of thought is that there was a huge surplus of carbon dioxide in the atmosphere during the age of the dinosaurs. This meant that vegetation flourished, and herbivores such as the sauropods simply had an over-abundance of nourishment available to eat. While somewhat of a burden in terms of manoeuvrability, their size would certainly have helped to some extent when fending off smaller carnivores. This leads to another proposal from palaeontologists, namely that some dinosaurs grew in size over millions of years as a form of self-defence.

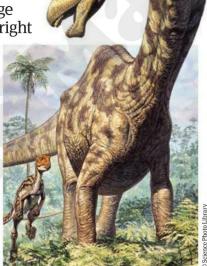
However, others think that these giant dinosaurs were cold-blooded, which was directly responsible for their size. Indeed, warm-blooded animals simply wouldn't be able to sustain such mammoth sizes, somewhat backed up by the lack of mammals larger than a few tons today. Huge cold-blooded sauropods, weighing in at up to 100 tons, would have been almost self-sustainable, as they could store heat throughout the day for the colder nights, maintaining a fairly unchanged body temperature and prolonging their survival.

Turn over for our look at the truly humongous beasts that would wreak endless havoc if they roamed our planet today.

How are they supported?

We examine the anatomy of a sauropod, to see how these huge creatures were able to keep upright







The spinosaurus is often overlooked as the largest carnivorous dinosaur in favour of its more famous cousin, the tyrannosaurus rex. However, the spinosaurus would have dwarfed the popular movie star, measuring 16m (52ft) in length compared to 12m (39ft) for a T-rex. That being said, the characteristic features of the spinosaurus – namely its fin-like spinal protrusion – make it one of the most recognisable theropods. In the late-Cretaceous period, this 12-ton creature would have been fairly common, with its sail-like spine adding to a fearsome display and possibly helping to regulate its body temperature.

Teeth

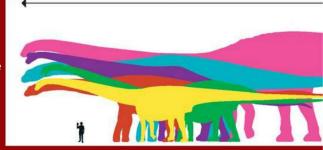
Within its crocodile-like snout, an unusual feature for a theropod, were rows of conical teeth for hunting and killing fish and average-sized land-based dinosaurs.

Fee

At the base of the strong hind legs of the spinosaur were three long, forward-facing claws.

The other contenders

There is some contention among paleontologists as to what the largest dinosaur of all time was. Currently the official record-holder is the 100-ton behemoth that is argentinosaurus. However, there have been several other claims to the throne over the years. In the late-19th Century, a paleontologist known as Edward Cope claimed to have found part of a vertebra that suggested he had unearthed a sauropod dinosaur (known as 'amphicoelias') measuring a humongous 62m (203ft). Mysteriously, however, this bone 'disappeared' shortly afterwards, leading some to believe he had falsified the claim to get one over on his chief paleontological rival at the time, Othniel Marsh. It will be interesting to see if any more evidence of this giant creature is unearthed in future. Another contender that little is known about is bruhathkayosaurus, which may possibly be the heaviest dinosaur ever discovered, coming in at up to a gigantic 220 tons.





1. Liopleurodon 25-ton sea-dweller the liopleurodon reached ngths of up to 15m (49ft) when it ruled the waters in the late

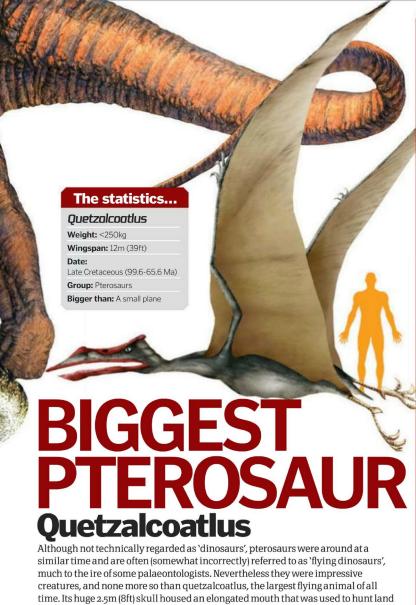


2. Shantungosaurus RAPTOR genus, this duck-billed herbivore was very common in the late Cretaceous period. It was about 15m (50 feet) long and weighed up to 50 tons

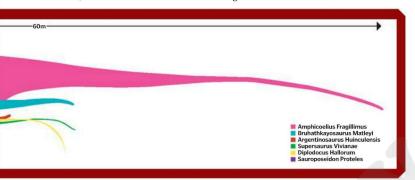


3. Utahraptor 680kg (1,499lb) and measuring 6m (20ft) in length, the utahraptor was the biggest raptor of

DID YOU KNOW? Despite its giant wings, some research has suggested that quetzalcoatlus was unable to fly



animals including dinosaurs and other vertebrates. Despite its size quetzalcoatlus was comparatively light as its bones were comprised of a series of air sacs, a useful feature for such a colossal creature aiming to take to the skies. While most other pterosaurs fed on fish, quetzalcoatlus was somewhat unique in its hunting of land animals, no doubt useful nutrition to fuel its giant metabolic needs.



Dinosaur identification



Mike Benton, Professor of Vertebrate Palaeontology in the School of Earth Science at the University of Bristol, UK, explains how palaeontologists can estimate the approximate size of a dinosaur from fossils and other evidence

Can you describe your role within palaeontology?

I work in a 50:50 teaching and research position - I teach undergraduates, both geologists and keen palaeontologists, and especially I teach Masters and PhD students. Every year, some 20-25 new Masters students and four-five new PhD students come from all parts of the world to work with us, and I really enjoy working with them to help them develop their careers. In research, I work on several topics by myself, on others with my students, and on others with collaborators around the world.

Could you briefly summarise the key methods and techniques used in the identification of prehistoric creatures?

Palaeontologists identify fossils based on the existing knowledge of living and extinct forms. The fossils are often incomplete, and usually show only the hard parts. But, if there is a living relative, these parts can be identified, and a fair attempt made to identify what the fossil is.

Can you describe some of the challenges involved in identifying a dinosaur?

Dinosaurs are all extinct, and their closest living relatives, the birds, are so different that it is hard to make useful comparisons in many cases. But, when complete skeletons are known, all the bones can be identified from knowledge of living forms, and the skeleton can be reconstructed. This shows basic things, such as whether the animal walked on all fours or on its hind limbs only, what it ate, and whether it could have used its hands for grasping things.

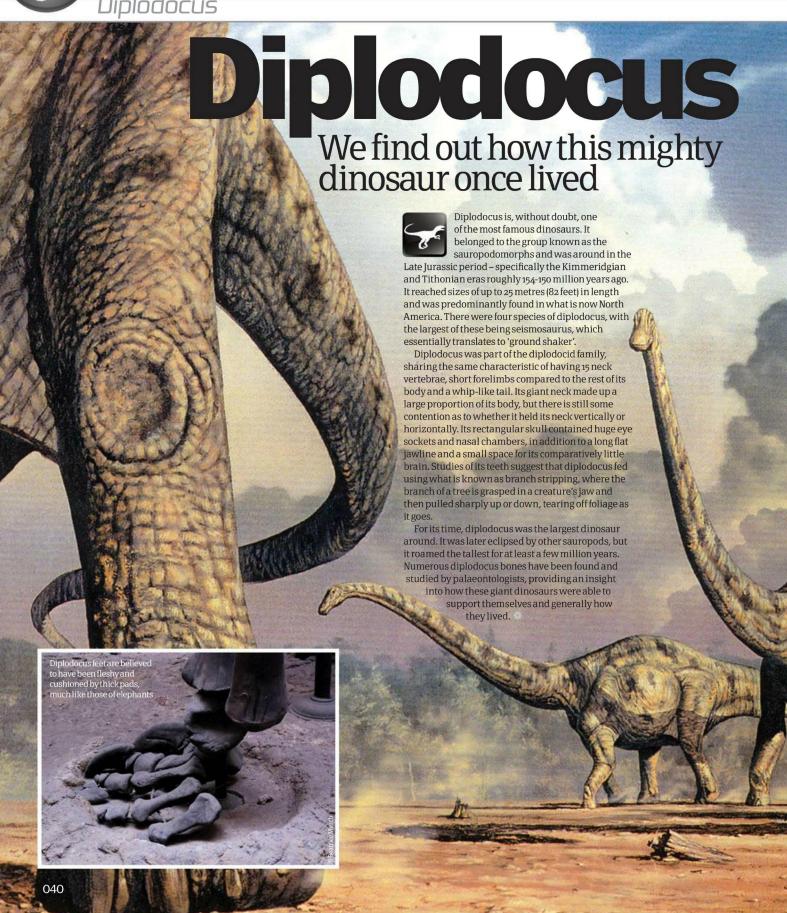
How are paleontologists able to discern how large a dinosaur is, and its diet?

The dinosaur skeleton will itself be large or small. The best guide to body weight for a fossil form is to measure the leg bones. The femur (thigh bone) is particularly useful - because weight (= mass) is a three-dimensional measure, we look for something that increases and decreases in proportion to mass, and that is the diameter of the femur. So you get a good relationship between femur head diameter and body mass from living birds, crocodiles and mammals, and dinosaur body weights can then be estimated from this regular relationship. Diet is determined from overall tooth shape - curved and pointy for meat-eating, and broader for plant-eating. It's hard to be more precise, because we don't have the data set of comparative information to tell exact plant food from wear marks and scratches on the tooth enamel (used for determining the exact diet of mammals).

What, in your opinion, are the most important discoveries made in the past 50 years?

First, the realisation that dinosaurs were active and dynamic animals, dating from the work of John Ostrom in 1969 on deinonychus, and Bob Bakker in the Seventies on dinosaur warm-bloodedness. Second, the paper by Luis Alvarez and colleagues in 1980 that showed the first evidence that the Earth had been hit by an asteroid 65 million years ago. This has been much confirmed since then, and even the crater has been identified, all showing the key role of this in causing the extinction of the dinosaurs.

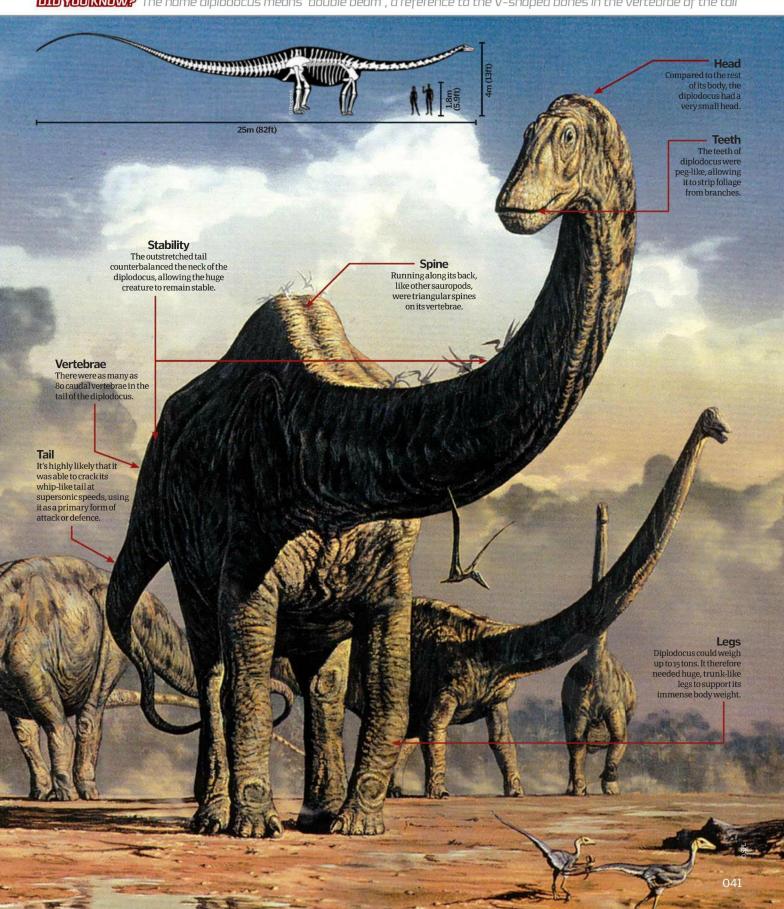




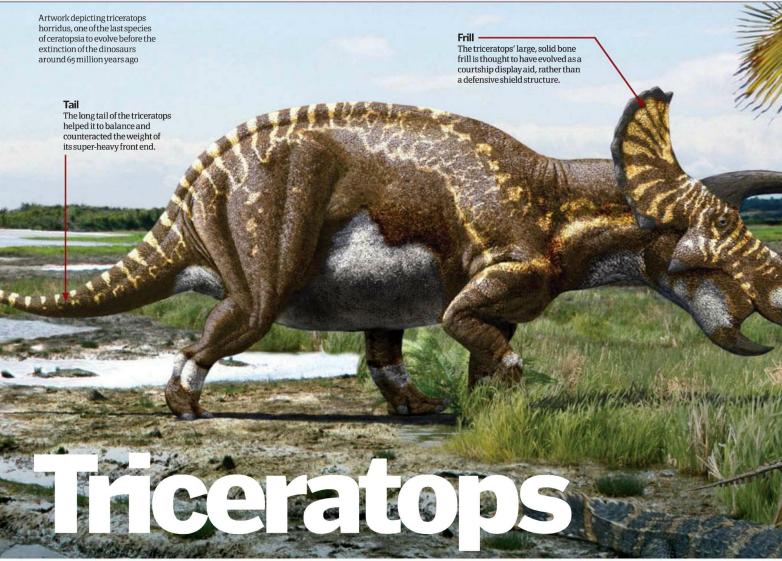


Biggest dinosaurThe largest confirmed dinosaur is Argentinosaurus, which is estimated to have reached lengths of 35m (115ft). As its name suggests, it roamed across South America, and it was alive approximately 97-94 million years ago.

DIDYOUKNOW? The name diplodocus means 'double beam', a reference to the V-shaped bones in the vertebrae of the tail







One of the most well-known dinosaurs, the triceratops was a herbivorous titan that was very well equipped for a fight



Triceratops is a genus of herbivorous dinosaur that comprises two validated species - triceratops horridus and triceratops prorsus, both of which roamed Earth during the Late Cretaceous period (68-65 Ma) before being eradicated in the K-T

mass-extinction event that wiped out all dinosaurs. Triceratops were large, rhinoceros-like animals that weighed many tons - a fully grown adult would be expected to weigh in the region of seven tons. They were heavily armoured with reinforced bone horns, which could exceed 70 centimetres (28 inches) and a solid bone frill, and hugely powerful thanks to their sturdy frame. These traits, combined, made both species of triceratops a fearsome foe to potential predators, capable of puncturing flesh and shattering bone with their sharp horns when charging.

In terms of anatomy (for a comprehensive rundown, see the 'Triceratops anatomy' illustration), the triceratops genus is incredibly interesting, not least because many of its parts' functions are still debated today in the field of palaeontology. A good example of this can be seen by analysing a typical triceratops skull, whichaside from typically measuring a whopping two metres (6.6 feet) in length – sported three horns as well as a fluted, extravagant rear frill.

The horns, from which the genus gets its name, and frill have been successfully argued by palaeontologists to have been used for self-defence against predators, with close examination of unearthed specimens revealing battle scars, cuts, punctures and cracks. However, modern scholars also postulate that both skull features, along with the elongated nature of the skull itself, most likely

also evolved as courtship aids, with potential mates selected on the size and shape of these features. It has also been suggested that the frill may have helped triceratops regulate their body temperature in a similar manner to the plate-laden stegosaurus (whose name translates as roof, or covered, lizard).

Other anatomical areas of interest lie in this dinosaur's large bird-like beak and hips. Indeed, it is because of these particular features that this genus has been used as a reference point in the definition of all dinosaurs - ie all dinosaurs are descendants of the most recent common ancestor of triceratops and, as such, this common ancestor is also that of birds prevalent throughout the world today. It's important to note here that modern birds did not descend from triceratops directly, but rather from its common ancestor with all other dinosaurs; today's birds in fact originate from saurischian dinosaurs.

TRICERATOPS

Fight!

discovered with T-rex bite marks and even one where the herbivore had had one of its brow

horns snapped off entirely.

Artist Charles R Knight depicted a triceratops and T-rex squaring up for a fight in a 1901 painting. In reality, these two dinosaurs were not prominent adversaries.

The triceratops genus existed during the Late Cretaceous period in what is now North America. Many finds are discovered in the Hell Creek Formation in Montana, USA.

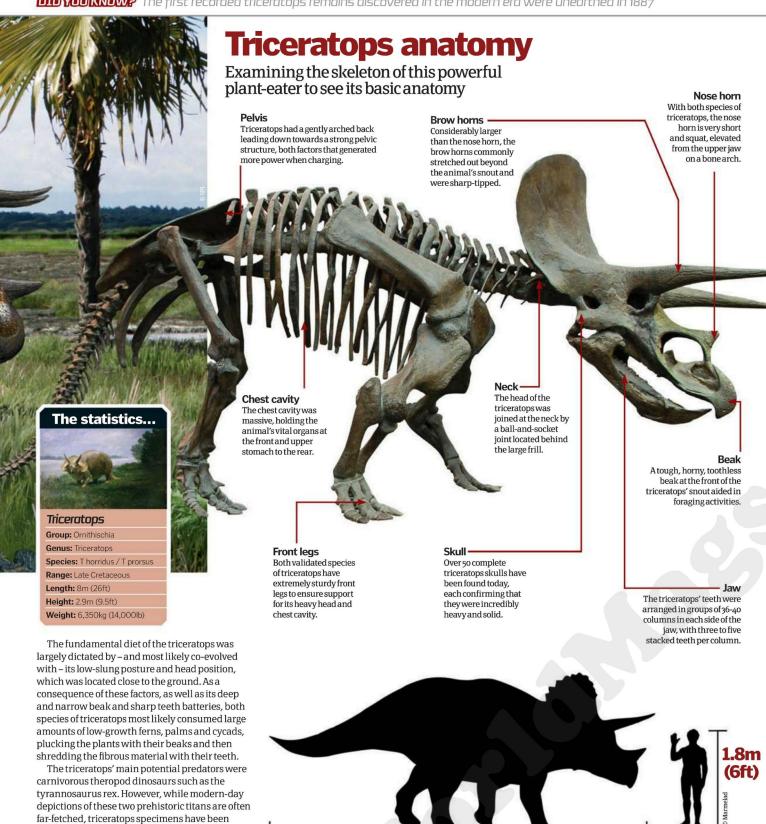
3 Despite many species being named, only two species of triceratops are considered valid by palaeontologists. These are triceratops horridus and triceratops prorsus.

Origins

The evolutionary origins of the triceratops are considered to be in Asia during the Jurassic period. However, they only became horned animals in the Late Cretaceous.

Despite TV shows and movies commonly depicting triceratops as herding animals, there is actually very little recorded evidence that supports this claim.

DIDYOU KNOW? The first recorded triceratops remains discovered in the modern era were unearthed in 1887





How T-rex hunted prey

The T-rex may have been one of the largest meateating dinosaurs, but it might not have been a predator at all



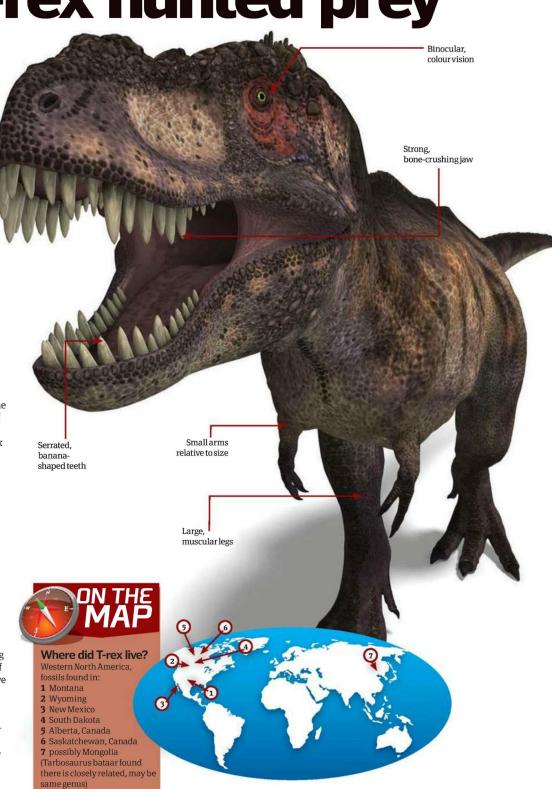
Tyrannosaurus rex – from Greek and Latin words meaning 'tyrant', 'lizard' and 'king' – was one of

the largest carnivorous dinosaurs to walk the earth. It lived about 85 to 65 million years ago, in lightly forested North American river valleys and plains. The T-rex stood more than four metres tall and 12 metres long, weighing in at five to seven metric tons. Some fossil evidence shows that the female T-rex may have been the larger of the sexes, although there's no way to know for sure. Its bananashaped, serrated teeth gripped flesh and its massive jaw crushed bones as it downed more than 200 kilos of meat in one gulp. Likely prey included the Triceratops horridus and the Torosaurus, each about the size of an elephant.

There have been several nearly complete Tyrannosaurus rex skeletons found since the first bones were discovered in 1894, some of which included soft tissue. From these, palaeontologists have learned that the T-rex had a lot of bird-like traits. It likely had a one-way air sac system that kept its lungs constantly full of fresh air, hollow bones to lighten its body weight, and binocular, colour sight. It also had a wishbone, or furcula. Some palaeontologists believe that our assumptions of scaly, lizard-like skin might not be entirely accurate and that T-rex could've even had feathers.

Controversy about the T-rex centres on whether it was a predator or a scavenger, as well as whether it moved slowly or quickly. Many palaeontologists believe that the Tyrannosaurus rex was strictly a predator, but those who question this assumption point to its short, weak arms with two-fingered hands, large legs suited for walking distances and a strongly developed sense of smell. These seem more in line with what we know of scavengers rather than predators.

Others argue that muscle scars found on skeletons show that the T-rex had strong arms. They also believe that their binocular sight and hollow bones indicate a fastermoving predator. However, predators today will sometimes scavenge if fresh prey isn't around, so there's the possibility that T-rex could've actually been both.



Head to Head WINGSPAN



1. Pteranodon pteranodon had a to a measly nine metres although this was still



2. Ornithocheirus allowed this reptile to rule the sky in the Early Cretaceous period. Poor fossil material has made more information on this



3. Quetzalcoatlus Not a word you'd want to a in a spelling competition. With a wingspan approaching 15 metres, this giant creature was approximately the size of a

their legs and their body.

bones filled with air sacs.

not the largest pterosaur.

them out of the water

DIDYOUKNOW? The word pterosaur comes from the Greek word pterosauros, meaning 'winged lizard



had a large crest on its head



Mammoths

Back The hind legs of

mammoths were shorter

than those at the front,

which is a sloping back running from the

the consequence of

shoulders to hips.

Now extinct, mammoths used to roam the Earth with the frequency and variety of their modern relatives, elephants

Until their total extinction, mammoths were a highly successful and widespread species, found from central Africa, through Europe onto North America. Indeed, Mammuthus lived throughout the entire Pliocene and Pleistocene epochs -

over 5 million years - and diversified into many species of various appearances and sizes. However, through a myriad of factors including climate change, disease and human hunting, the majority of the last mammoths - which were woolly mammoths living in Siberia - were wiped out between 8,000 to 10,000 years ago. From the frozen remains of examples



found in the 20th and 21st Centuries (specimens are preserved in mummified states in Siberian permafrost), mammoth DNA has been ratified by scientists to be almost identical to that of modern elephants, with their appearance being closely linked.



A mammoth excavation in Siberia

5m 4m 3m

2m

A FIRM Mammuthus Sungari was the largest variety of mammoth and stood at over five metres tall

Mammoths tended to sport a fatty lump at the top of their spine that was used to store energy. This, as with the camels of today, allowed them to traverse many miles with no food or water

> Leas Due to their mighty weight (over eight tons) and colossal height (over five metres), the legs of mammoths were massive columns of flesh, muscle and bone.

Feet Mammoths had four-toed feet.

splayed outwards like those of a human to aid balance. Head to Head PREHISTORIC ANIMALS



So big and heavy that only large groups of predatory animals such as humans or sabre-toothed tigers could take it down, the mammoth

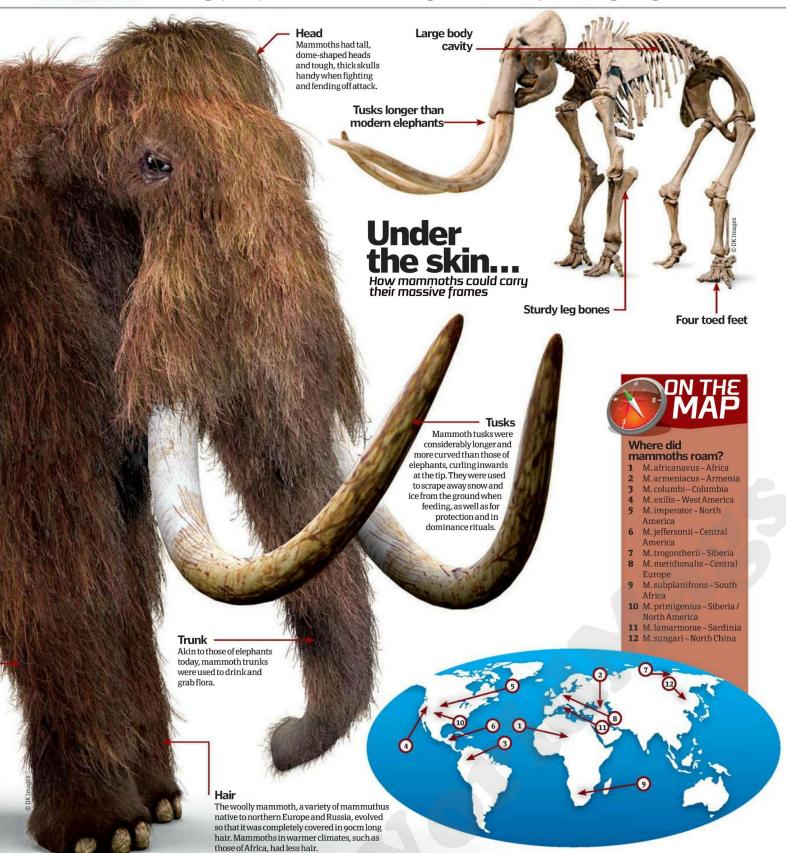


2. Sabre-toothed tiger was named after the size and shape of its



3. Dodo A one-metre high flightless bird that is closely related to the pigeon, the dodo existed from 12,000 years ago up until the end of the 17th Century.

DIDYOUKNOW? One variety of dwarf mammoth survived on Wrangel Island, Alaska, up until 4,500 years ago



BUILDINGS, PLACES & LANDINARKS

050 Inside a medieval castle

Take a look at what went on behind the walls

052 Medieval monastery

What could you find in these religious sites?

054 Karnak

The largest temple complex in the world

056 St Paul's Cathedral

Discover how Christopher Wren's vision was realised

058 Westminster Abbey

A guide to the Coronation church of the monarchy

060 Salisbury Cathedral

The story of this impressive English cathedral

062 Notre Dame

Find out how this Parisian church was constructed

064 The Bastille

Learn how the Bastille acted as a defence for Paris

065 The Eiffel Tower

See how this iconic structure was built

066 Tower Bridge

The most famous bridge across the Thames

068 Tudor houses

The techniques behind building a Tudor home

070 The Taj Mahal

The story behind India's stunning landmark

072 The Great Wall of China

Building the longest manmade structure on Earth

073 Leaning Tower of Pisa

Explaining why this tower leans and what went wrong

074 How Venice was built

The planning needed to create a city on water

076 Inside the Colosseum

The magnificent icon of Imperial Rome

078 Pompeii

How did Vesuvius wipe out this Roman city?

079 Petra

Read about how this city was carved into the rocks

080 The White House

Take a tour of the home of the President of the United States

082 Mount Rushmore

Discover how were these giant faces carved

083 Statue of Liberty

The story behind this French gift to the US

084 Easter Island's statues

A look at what these stone monoliths represent

085 Tutankhamun's tomb

Inside the Houses of Eternity

086 The South Pole

Captain Scott's pioneering expedition explained

088 Stonehenge

Find out how – and why – Stonehenge was formed

089 Shropshire's Iron Bridge

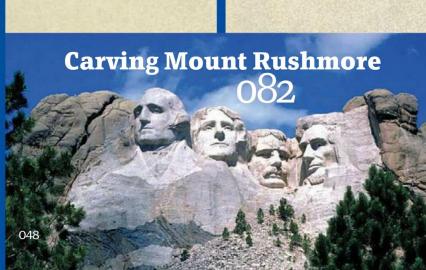
The bridge that defined Britain's industrial potential

089 Big Ben

Discover how London's bell came to be

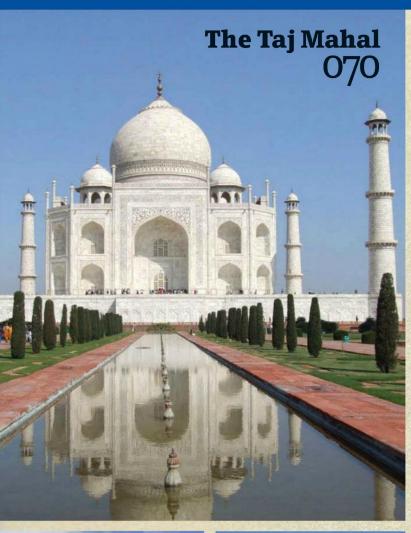
089 Hadrian's Wall

Was this a historic form of border control?

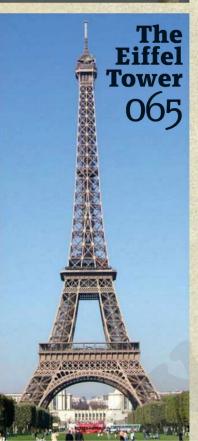


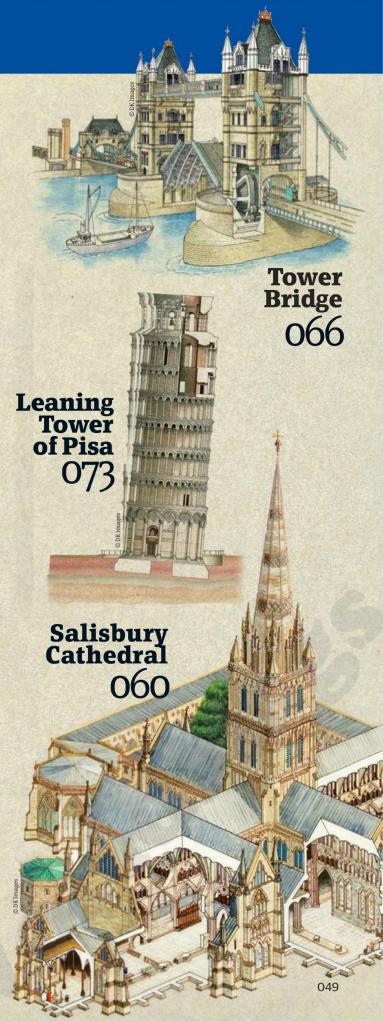














Medieval castle



The inner wall

Up to four metres thick, with seven guard towers, the innerwall can only be reached by going through a dark passageway and the great square tower, making it difficult for intruders to find their way to the keep

Master's lodgings This room on the second floor of the keep is circular. Unlike many residential quarters in castles, it is elaborately and elegantly decorated.

Moat

This moat is at the south end between the outer and inner wall. Horses drank from it, and the water was used to fill baths.

Stone slope

Crusaders built this 24-metre thick stone slope to protect the castle's south side. Its smoothness made it difficult for invaders to scale.

Why did castles die-out?

Gunpowder came into use in the 13th Century and spelled the end of castles as military strongholds. Thick, high stone walls could withstand the forces of catapults and trebuchets, but did not hold us as well against cannon fire. Some castles functioned solely as private residences for nobles and were built on aesthetic principles. Defensive castles evolved into castle-fortresses, with low-angled walls and rounded towers.

DID YOU KNOW?



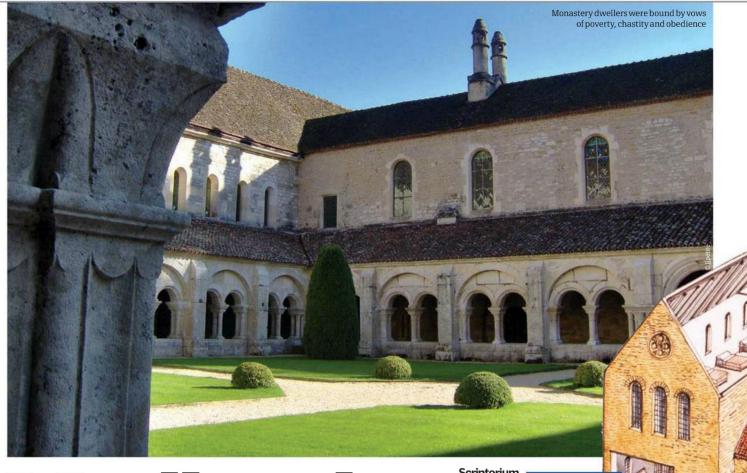
The world's largest castle...

According to Guinness World Records, the world's largest castle is Prague Castle. Built around 880 CE by Prince Borivoj, Prague Castle is actually a complex of towers, palaces and other buildings in various architectural styles. It covers nearly 70,000 square metres.





Monasteries



Medieval monastery

Scriptorium

A room for copying books. It was often attached to, or near, the library.

Kitchen

Normally close to the refectory, all food eaten in the monastery was prepared in the kitchen by the monks.

A life of rigorous schedules and self-sacrifice, the monastery was the intellectual and cultural powerhouse of medieval Europe

A monastery is a building inhabited by a community of men or women, devoted to the service of God and bound by a three-fold vow of poverty, chastity and obedience to a superior, and to a rule. The majority of medieval monks followed the Rule of St Benedict, written in the 6th Century. The standard features of the monastic plan were a smooth blend of spiritual necessity and common sense. The dominant building was the church, as it was where the monks spent the largest part of their waking hours in worship. Next to the church stood the cloister garth (garden), lined by four walkways which provided

covered access to the surrounding buildings. These included the chapter house, dormitory, latrines, refectory and kitchen. Store rooms, an abbot's house and guests' quarters might also be attached. The infirmary, or monastic hospital, often stood to the east of the main buildings to provide peace and quiet to its patients. Many other buildings stood in the precinct, such as chapels, barns and stables, and most monasteries were surrounded by a high precinct wall, entered through an impressive gatehouse.

Built from stone and intended to both glorify God and remain serviceable for centuries, monasteries

were constructed using the prevailing style of the day, often pushing architecture to the limit. Walls and vaults were built from stone, roofs were covered in lead, windows were glazed, and the floors covered with encaustic tiles. Monasteries not only acted as houses of prayer and pilgrimage destinations, but also cultural centres, providing education and employment. Many towns, such as Abingdon, Oxford, St Albans, Reading, Westminster and Chester (the list goes on) only exist because they grew up around a monastery. In a very real sense, monasteries physically defined the urban geography of modern Britain.

eating in silence while a reader

read aloud from a pulpit

also grown for their beauty,

and to decorate the church

The right address

Like calling a priest 'Father', the correct form of address for a monk is 'Dom'. This name comes from the Latin term 'Domnus', meaning sir or master.

Monastic order

Only one religious order was founded in medieval England. Established by St Gilbert of Sempringham, 'Gilbertine monasteries were 'double houses' for men and women.

Britain's oldest monastery?

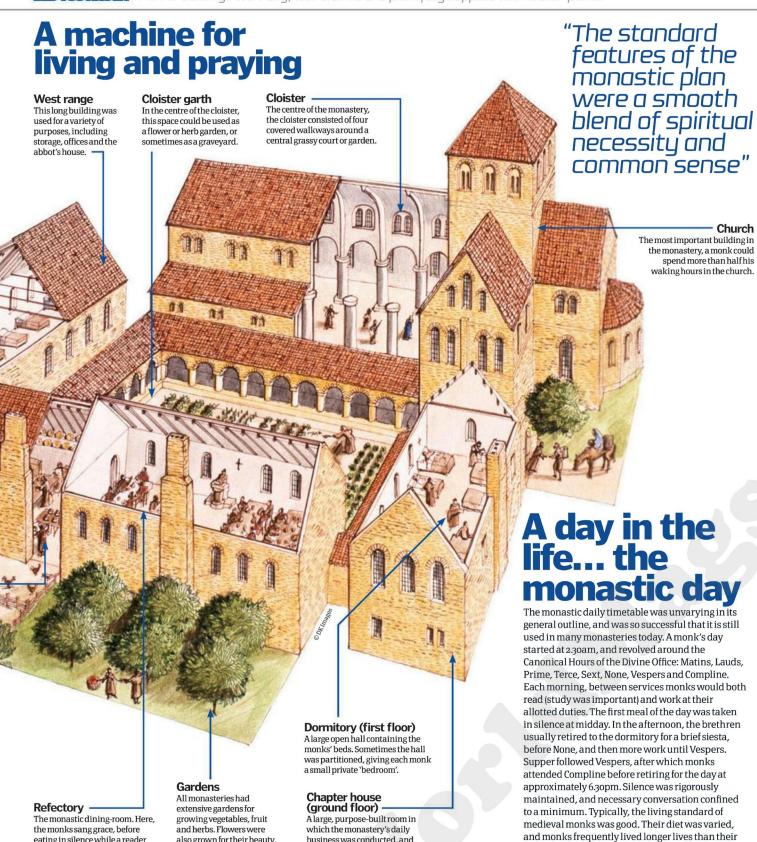
Traditionally, Glastonbury Abbey in Somerset claims to be the first church (and monastery) in Britain. Modern archaeology has gone some way to confirm this claim.

The first clocks created in medieval England were the work of monks. Richard of Wallingford built a clock in c1320. It became the first public clock in the country.

Footwear

Monks wore working boots in the fields, leather shoes in the monastery, and night shoes or 'slippers' in church. The Hollywood image of a monk wearing sandals is a modern myth.

DID YOU KNOW? Monks' buildings were airy, well drained and plentifully supplied with water-points



business was conducted, and

important guests were received.

secular counterparts.

Kamak: the temple of light

Taking a closer look at the construction of the largest temple complex in the world



In ancient times the temple at Karnak was known as Ipet-Isut – 'most divine of places'.

The temple housed the cult of Amun-Re, the most important deity in Thebes and dedicated to various gods and goddesses.

Egyptian cult temples all share a similar design. However, as Karnak began to grow in importance, the edifice grew larger and more complex. Each pharaoh extended the temple in an attempt to outdo their predecessors in personal piety. Eager to impress the gods. each king embellished the temple with beautiful masonry and enormous pylons - they decorated the complex with elaborate imagery and military texts. The temple acted as a 'generator' of spiritual energy. It was seen as a bridge between the Earth and cosmic realms. Highly visible to the populace, its walls were designed to promote both awe and fear.

At Karnak, a religious ceremony would have commemorated the establishment of the first temple stone. The foundations consisted of sand-filled trenches; although primitive, these proved highly substantial. The temple pylons (weighing thousands of tons) are still standing. Pylons, columns, subsidiary temples and chapels were crafted in sandstone, basalt and granite. Mined from established quarries, the stones were removed in blocks using stone-tipped drills and pounders. Monolithic blocks (used for colossal statuary) were excavated in one single piece. The building materials themselves were transported to the temple by river.

The temple walls consisted of large slabs of stone that were chiselled with mallets and hammers; they were then inscribed with religious and military scenes that were designed to promote the pharaoh as a devout ruler and warrior. Each eighteenth-dynasty pharaoh added extra buildings to the temple - for example, the long-lived Ramesses II created the enormous Hypostyle Hall that dominates the site today. In most cases the stone walls were erected in a series of decorated blocks that were interlocked, the $craftsmen\,using\,very\,little\,mortar.$ The masons employed metal chisels and wooden set squares; they laid out their blocks checking angles and corners. The Egyptians didn't use pulleys to construct columns or colossal statuary, but employed levers and rollers to raise large stone monuments. As the eighteenth dynasty progressed, the temple complex began to extend across the East Bank at Thebes. Construction workers erected obelisks, enormous statuary and a sacred lake.

Karnak typifies the ancient Egyptian temple. It bears the standard features of most ancient Egyptian religious buildings, yet surpasses all others in terms of grandeur and scale, remaining an incredible sight to behold.



Ram-headed sphinxes line the temple's causeway

The layout of Karnak

Dissecting this intricate complex

Door of temple

The temple door was an impressive structure. This enormous portal, often made of cedarwood, was decorated with studs and sealed with large metal holts.

Temple pylon -

The pylon was a highly visible and impressive structure. Decorated with military scenes, it was adorned by flagpoles.

Decoration of the temple pylon

The pylon was highly visible. For foreign dignitaries, newly arrived in Egypt, it contained a warning. It was decorated with the image of the pharaoh smiting his enemies.

Head to Head THE SUN GODS



One of the oldest deities, Horus was shown as a falcon. With his outstretched wings, he traversed the sky as a sun god.



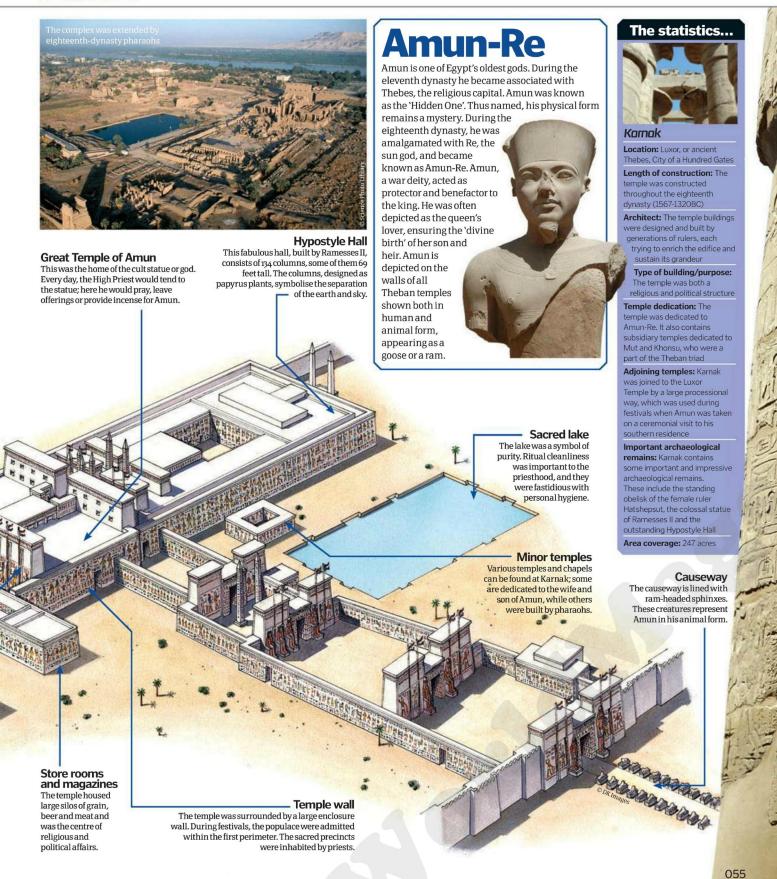
2. ReClosely connected to the pharaoh, the Egyptian sun god Re was a creator deity who emerged from the primeval waters at the beginning of time.



3. Aten
Shown as a radiant sun disk, the Aten was revered by the heretic pharaoh Akhenaten who dedicated

temples, tombs and hymns

DIDYOU KNOW? It is estimated that 50 people could stand together on the capitals of the columns in the Hypostyle Hall





St Paul's Cathedral

St Paul 75 Cathedral Cathedral Constructed from wood and lead, the dome appears to support the stone lantern above which it rises. Cathedral Cathedral

London's crowning glory, St Paul's stands as a monument to one man's genius



Sir Christopher Wren produced three designs for his new cathedral. The

first two were rejected and the cathedral as built only bears a small resemblance to the third.

Built mainly of Portland stone, St Paul's contains many idiosyncrasies – two of the most familiar features, for example, are misleading. The outer walls are built in two distinct storeys, but the upper storey is false, it simply acts as a screen to hide the flying buttresses that support the high vaults. On the other hand, the iconic dome – which crowns the outside of the cathedral – is not the one inside; the interior dome is positioned much lower for aesthetic effect.

Wren gathered leading artists and craftsmen to work on the building. Perhaps the best known today are Grinling Gibbons, responsible for the woodwork; Francis Bird, who sculpted the great west pediment; and Sir James Thornhill, who painted the life of St Paul on the interior of the dome. Taking just 35 years to complete, the interior is much as Wren left it; the Victorians added some stained glass windows and mosaic decoration to the roof in the choir and above the main arches of the dome, but they blend well with Wren's grand conception.

Whispering gallery

30.2m above the floor, a whisper on one side of the gallery can be heard on the other.

Inner dome The inner dome

provides an artistically balanced interior, painted with eight monochrome paintings of the life of St Paul

Inner cone

A brick cone supports both the outer dome and the stone lantern above it. It is invisible from the interior.

South west tower

 $This tower houses the cathedral clock \\ and contains Great Paul, at 16 ^1/2 tons \\ the largest bell in the British Isles.$

Inside St Paul's



Originally designed with six giant columns, the

long enough to span the intercolumniations.

Portland quarries could not produce blocks of stone

pediment

The 'Conversion of St

Paul' is one of the best

examples of Baroque

sculpture in Britain.

West front

London's first cathedral was built in 604, but this building or its successor was burned down in 1087. A great Norman cathedral known as 'Old St Paul's' was then built on Ludgate Hill. The choir was reconstructed in the 13th Century to provide more space, the total length reaching 178m. The spire added to the central tower in 1315 reached 149m; there were also two west towers, two cloisters

and a two-storey Chapter House. In the 17th Century, Inigo Jones commissioned to improve the cathedral, refaced the nave and west end in classical style and erected a grand portico. After the Commonwealth, Wren made ready to continue these plans by casing the nave with Renaissance detail and building a dome to replace the tower, but his work was terminated by the Great Fire of 1666.



5 TOP FACTS ST PAUL'S CATHEBRAL

Lord Nelson

After Lord Nelson died at the Battle of Trafalgar on 21 October 1805 he was buried in the centre of the crypt directly beneath the crossing and dome.

Duke of Wellington

In 1852, 1 million people watched the Duke of Wellington's funeral procession to St Paul's before he was interred in the crypt in a luxulyanite sarcophagus.

Attempted bombing

In 1913, suffragettes - in an attempt to bring attention to their cause - planted a bomb under the Bishop's throne in the choir. Luckily, it was defused before it exploded.

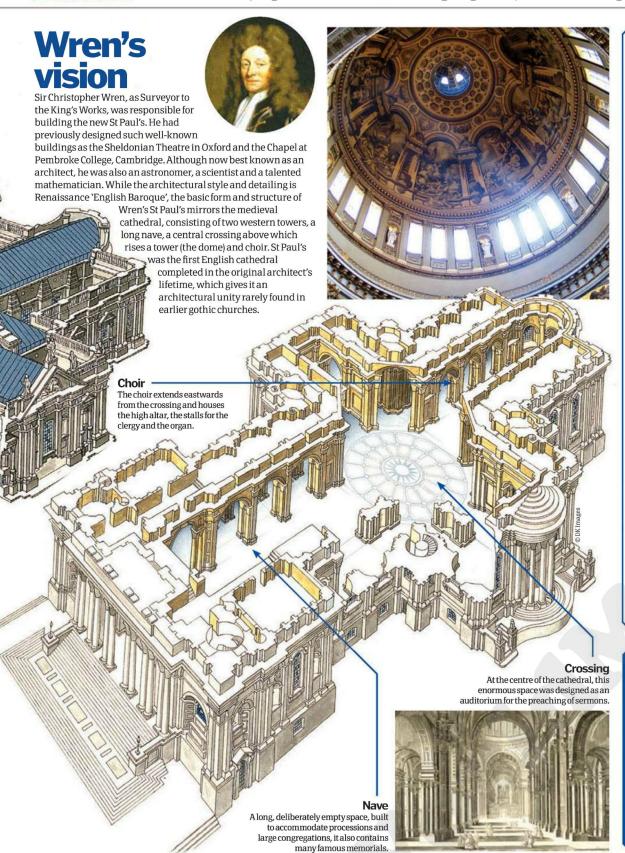
Sir Winston Churchill

4 Sir Winston Churchill's state funeral at St Paul's Cathedral on 30 January 1965 was the first to be broadcast to the nation on both radio and television.

The Royal wedding

Charles, Prince of Wales, married Lady Diana Spencer on 29 July 1981 after which St Paul's became one of the most visited churches in England.

DIDYOU KNOW? Lord Nelson's sarcophagus is second-hand; it was originally made for Cardinal Wolsey's tomb



The crypt

The crypt in St Paul's mirrors its medieval predecessor, which extended under the east end of the old cathedral. Wren's crypt, however, with its central cluster of Roman Doric pillars and simple piers below nave and choir, extends below the cathedral's full length and is the largest in Western Europe. Built using stones salvaged from the ruins of Old St Paul's, the crypt houses chapels and monuments. At the eastern end of the crypt is the OBE Chapel (Order of the British Empire). There are many notable graves in the crypt including those of Lord Nelson, the Duke of Wellington and Sir Alexander Fleming. Wren's grave with its famous epitaph is also to be found there: 'Reader, if you seek his memorial look around you'.



Lord Nelson's grave rests in St Paul's crypt

The Statistics

St Paul's Cathedral

Architect: Sir Christopher Wren (1632-1723)

Years of construction:

Type of building/purpose: Cathedral church of St Paul the Apostle, for the Anglican Diocese

Location: Ludgate Hill, London Full height: 111m

Area of site: 25,697m²
Cost of construction:

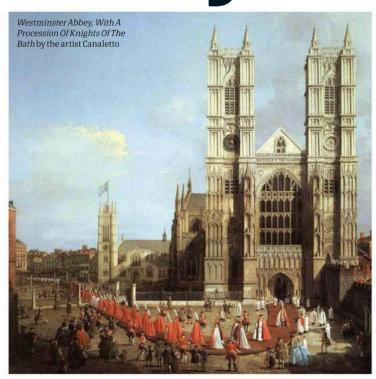
£738,845 (approx £87 million in



Westminster Abbey

Westminster

A House of Kings, Westminster Abbey is the Coronation church of the British monarchy





The Collegiate Church of St Peter at Westminster, almost always referred to as 'Westminster Abbey', stands

just to the west of the Palace of Westminster. It is the traditional coronation and burial church for English, and later British, monarchs. The abbey's foundation dates from 960, when St Dunstan established a group of 12 Benedictine monks on 'Thorney Island', a marshy spot by the River Thames. King Edward the Confessor began rebuilding the monastery in 1045 and was buried there after his death—he was canonised in 1161. St Edward's shrine later became the focus for religious ritual and royal burials.

In 1245, Henry III started building the present church. The design is based on the continental models, but its English features include single rather than double aisles and a long nave with wide projecting transepts. The abbey has the highest Gothic vault in England, at 31

metres (nearly 102 feet), and it was made to seem higher by making the aisles narrow. The sculptured stonework – which came from Caen in France, Reigate in Surrey and the Isle of Purbeck – would have originally been brightly coloured. The walls were adorned with fine paintings and brilliant ruby and sapphire glass, with heraldic shields filling the windows. Most of the medieval decoration has disappeared and today the abbey is filled with later monuments and works of art.

The abbey briefly became a cathedral between 1546 and 1556, after which it was made collegiate, governed by a Dean and four Canons. The abbey is also a 'Royal Peculiar', a church directly responsible to the sovereign, rather than a bishop. It has become one of Britain's most significant honours to be buried or commemorated in Westminster Abbey, alongside Queen Elizabeth I, Sir Isaac Newton and Charles Darwin.

Gothic architecture

Formed by King Henry III, the abbey is a great example of Gothic architecture, characterised by slender vertical piers, counterbalancing buttresses and vaulting and pointed arches. Following the basic medieval Gothic church design of nave, transepts and choir, it is vaulted throughout in stone and roofed in lead. The interior was designed to be used as a spectacular setting for the shrine of St Edward the Confessor and to contain altars, chapel screens, tombs and monuments. Despite it taking nearly 150 years to complete the body, the general design of Henry III's masons was followed, making it one of the best examples of Gothic architecture in Britain.



Daily services are held in the choir. The choir stalls (seats) are carved wood, painted and covered in gold leaf.



Western towers

Designed by Nicholas Hawksmoor and built between 1722 and 1745, these are constructed from Portland stone and are early Gothic revival in style.

Coronation of William the Conqueror

After King Harold's defeat at the battle of Hastings, William vas crowned in King Edward the Confessor's abbey church on Christmas day 1066.

Death of Henry IV

2 It was predicted that Henry IV would die in Jerusalem, so when he collapsed in the abbey, he was taken to the aptly named Jerusalem chamber.

Burial of the 'mummified' queen

Queen Catherine de Valois died in 1437 but was only buried in 1778. In 1669, Samuel Pepys recorded how he was ved to kiss her mummy.

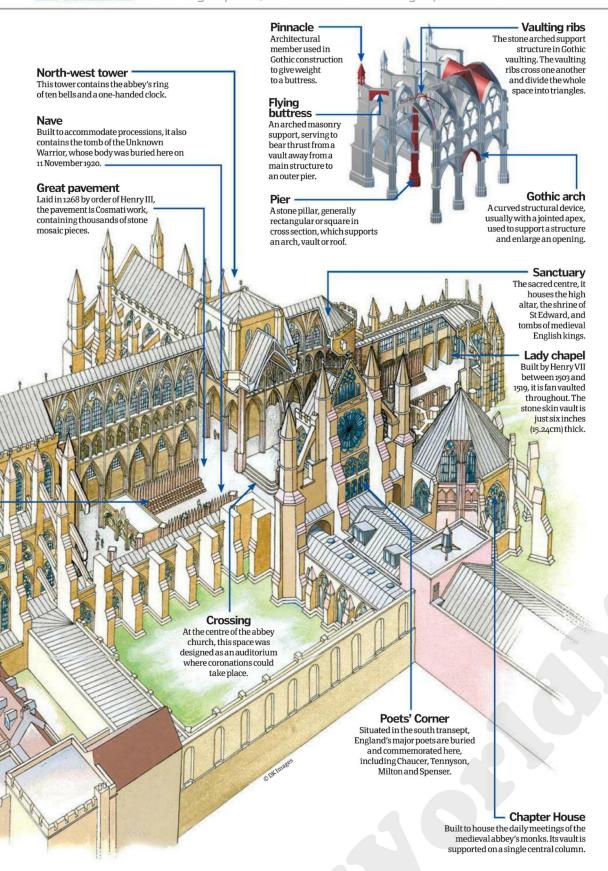
Double coronation

In 1689, Mary (James II's daughter) and her cousin and husband William of Orange succeeded to the throne Their joint coronation was the first and only at the abbey.

Stone of Scone Stolen

The stone upon which every monarch is crowned was stolen by Scottish Nationalists in 1950. It is now permanently housed at Edinburgh Castle unless needed for coronations.

DIDYOUKNOW? In The King's Speech, the scene set in the abbey before the coronation was actually filmed at Ely Cathedral





Royal weddings

The abbey has a long tradition as a venue for royal weddings. The first was the wedding of King Henry I and Matilda of Scotland on 11 November 1100. King Richard II and Anne of Bohemia married at Westminster on 20 January 1382, after which the abbey fell out of fashion as a venue for over 500 years. Royal weddings started again at the abbey in 1919, including the Queen and the Duke of Edinburgh on 20 November 1947. At the recent wedding of Prince William and Kate Middleton on 29 April 2011, the Dean of Westminster, the Dr John Hall, conducted the service while the Archbishop of Canterbury, Dr Rowan Williams, married the royal couple.

The statistics...



The Collegiate Church of St Peter, Westminster

Architect: Henry of Reyns (and many others)

Years of construction: 1245-1745

Type of building/purpose: Abbev/cathedral/collegiate

church

Location: Greater London

Full height:

69 metres (226 feet)

Area of site: 2,972 square meters (32,000 square feet)

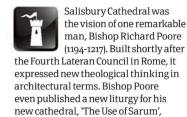
Cost of construction: Over £350,000,000 (modern money)



Salisbury Cathedral

Salisbury Cathedral

A new church for a new age, learn the story of the perfect English cathedral



which came to be used throughout medieval England.

The cathedral was laid out on a virgin site on water meadows, and remarkably the whole structure stands on foundations just 1.2m (4ft) deep. As the cathedral was built in just 38 years, its interior is stylistically coherent and is the finest extant example of early English Gothic architecture. It has 365 separate windows (the number of days in the year) and 8,760 marble pillars (the number of hours in a year). Constructed from 60,000 tons of Chilmark Stone and 10,000 tons of Purbeck 'Marble', over 420 tons of lead sheeting covers the cathedral's four acres of roof.

The tower and spire were constructed between 1310 and 1333, and added an extra 6,500 tons to the building causing subsidence, a problem from which the cathedral has suffered ever since. After the erection of the tower and spire in the mid-14th Century, the building was substantially complete. The only additions were the beautiful Hungerford and Beauchamp chantries at the east end, but they were sadly demolished in the late 18th Century, when James Wyatt, nicknamed 'the Destroyer', reordered both the cathedral's interior and the Cathedral Close. Moving medieval tombs and screens, Wyatt even demolished the cathedral's free-standing bell tower and levelled the graveyard. The cathedral was again restored by Sir George Gilbert Scott in the late 19th Century, and conservation work has continued ever since.

Inspiring artists and writers over the centuries, Salisbury Cathedral was used as the model for the fictional Kingsbridge Cathedral in Ken Follett's novel *The Pillars Of The Earth*.





A reconstruction of Old Sarum Cathedral, which was replaced by Salisbury Cathedral

Choir

The wooden choir stalls are the earliest complete set of choir furniture in England, constructed in 1236 and still in regular use today.

Chapter house

Built to house the meetings of the medieval cathedral's 52 canons, the stone vault is supported on a single slender pillar.

Vestry and treasury

This small octagonal building contained the medieval cathedral's most valuable treasures and vestments.

ngs also tisses today.

Trinity Chapel
This chapel was used to celebrate the daily Mass of Our Lady and contained the shrine of St Osmund of Salisbury, who died in 1009.

Magna Carta

The best preserved of the four surviving original copies of the Magna Carta (Latin for 'Great Charter') is housed in Salisbury Cathedral's Chapter House. At the time it was simply a solution to a political crisis, but it has become recognised as a cornerstone of liberty influencing much of the civilised world.

The Salisbury copy came to the cathedral because Elias of Dereham was at Runnymede in 1215 when the original was signed by King John. Elias was given the task of distributing copies of the charter and when he became a canon at Salisbury, he brought one with him. To help preserve the Magna Carta, the copy at Salisbury is kept in a temperature and humidity controlled environment, and away from the effects of UV radiation.



Head to Head RELIGIOUS BUILDINGS



1. Sagrada Familia, Spain signed by the architect toni Gaudi in a unique organic-Gothic style, work commenced in 1883, but it



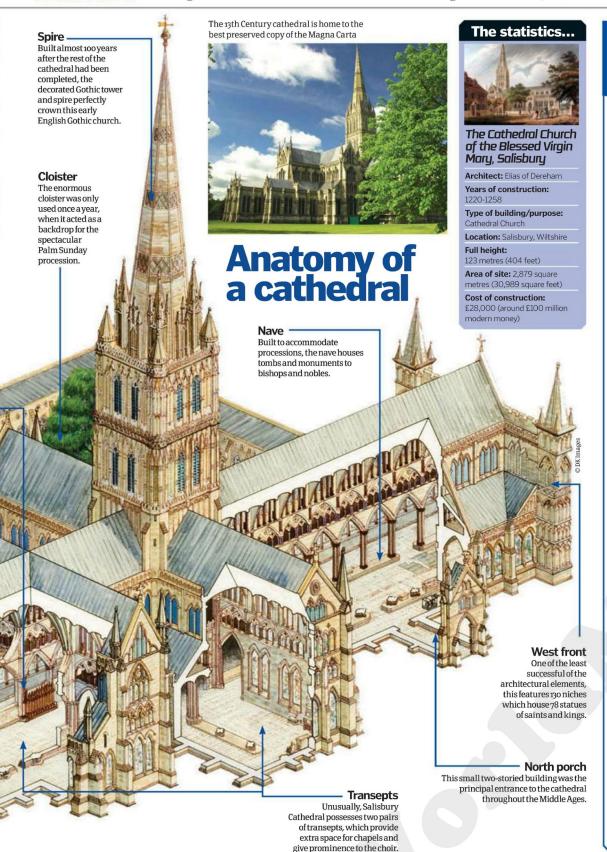
2. Mont-Saint-Michel, France monastery dedicated to the Archangel Michael is



3. Hagia Sophia, Turkey

biggest church in Christendom for almost a

DIDYOU KNOW? Salisbury Cathedral contains the world's oldest working clock. Built in 1386, it is still in use today



THE WORLD

1. St Peter's Basilica

Location: Vatican City, Rome Built: 1506-1626 Area: 21,095 square meters (227,065 square feet) Spire height: 138 meters (452 feet) Built to replace a church built by the Emperor Constantine, St Peter's Basilica is one of the holiest sites in Christianity. It contains the tomb of St Peter and many art treasures, including

2. Basilica of Our Lady of Aparecida

works by Michelangelo.

Location: Aparecida, Brazil Built: 1955-1980 Area: 12,000 square metres (129,167 square feet) Spire height: 100 metres (328 feet) The second largest church in the world, only just smaller than St Peter's Basilica, it can hold up to 45,000 people and is a major pilgrimage destination in South America.

3. Seville Cathedral

Location: Seville, Spain Built: 1401-1507 Area: 11, 520 square metres (124,000 square feet) Spire height: 105 metres (344 feet) The third largest church in the world, Seville Cathedral was built using a former mosque which stood on the site. It contains 80 individual chapels, along with the tomb of Christopher Columbus.

4. Cathedral of St John the Divine

Location: New York Built: 1892-unfinished Area: 11,200 square metres (120,555 square feet) Spire height: 70.7 metres (232 feet) Also known as 'St John the Unfinished', it is the largest Anglican church in the world and the seat of the Bishop of New York. Despite its huge size, about half has yet to be built.

5. Milan Cathedral

Location: Milan, Italy Built: 1386-1965 Area: 10,186 square metres (109,641 square feet) Spire height: 45 metres (148 feet) The cathedral church of the Archbishop of Milan, it took almost six centuries to complete and houses the shrine of St Ambrose. Built in many different architectural styles, the exterior and interior nevertheless harmonise remarkably well.



Notre Dame

The cathedral of Notre Dame de Paris

The most magnificent church in Paris throughout the Gothic age, Notre Dame defined what a cathedral should be



The Cathedral church of Our Lady, normally referred to simply as 'Notre Dame', stands

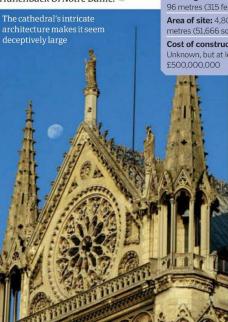
on the Ile de la Cite in the centre of Paris. The site had formerly been occupied by two ancient churches dedicated to St Stephen and St Mary, the origins of which stretch back to the 5th Century. The building of the present cathedral commenced in the middle of the 12th Century, when its foundation stone was laid by Pope Alexander III. At the time of its construction it was the biggest of all western churches, and it became the model for the Gothic cathedrals built throughout Europe.

The cathedral seems larger than it actually is through the clever use of double aisles, side chapels and transepts incorporated into the body of the church. Its western towers contain huge, highly decorative portals and a profusion of sculptural detail. The cathedral lacks a central tower and instead sports a distinctive pointed fleche (spire) made from wood and lead. The cathedral's roofs are made up of 1,326 slabs of lead, weighing more than 200,000kg (200 tons).

Throughout the Middle Ages, pilgrims flocked to the cathedral's miraculous image of St Mary and the shrine of St Marcel. Most of its medieval magnificence disappeared during the French Revolution, when the cathedral's demolition was seriously considered. Only in the 19th Century was the architectural

importance of Notre Dame realised. Heavily restored under architect Viollet-le-Duc, the cathedral took on its present form. Many of its most iconic features, such as its fantastic gargoyles, date from this restoration.

Despite its fame, Notre Dame was neither the coronation nor burial church of the French monarchy, and it was only in 1662 that the bishop of Paris was raised to the status of archbishop. Its outstanding beauty, however, has always been recognised, and it will forever be associated with Victor Hugo's novel The Hunchback Of Notre Dame.



The statistics...



Notre Dame de Paris

Architect:

Four unknown architects

Years of construction: 1163-1345 (with later additions)

Type of building/purpose: Cathedral church

Location: Paris, France

Full height:

96 metres (315 feet)

Area of site: 4,800 square metres (51,666 square feet)

Cost of construction:

Emmanuel bell

The south tower contains the medieval bell 'Emmanuel', which is only rung for major religious festivals and great events intimately associated with the French nation.

Side chapels •

There are 37 side chapels inserted between the cathedral's buttresses. All are regularly used to celebrate mass by the cathedral clergy

Notre Dame g timeline

Construction begins Bishop Maurice de Sully begins the building of the present cathedral to replace the ancient churches of St Stephen and St Mary

West Front finished The towers were completed in this

year and although they were intended to carry stone spires, these features were not included.



Coronation of Henry VI

The English king Henry VI is crowned in Notre Dame on 16 December, in an attempt to strengthen English claims to the French throne.

Great organ Comprising five keyboards, 190 ties and 8,000 pipes, it is the largest organ in France and one of the most famous organs

in the world.

5 TOP FACTS SRICHITECTURE

The name 'Gothic'

The term 'Gothic' used to describe medieval architecture was first coined in the 16th Century as a derogatory term, as it was thought inferior to 'Classical' architecture.

Gothic vaults

The highest internal Gothic vault constructed in the Middle Ages is at Beauvais Cathedral in northern France – it just exceeds 48 metres (157 feet).

'Perpendicular' Gothic

Developed in and exclusive to the British Isles, perpendicular buildings such as King's College Chapel, Cambridge, feature depressed arches and a strong vertical accent.

Gothic spires

The tallest spire in medieval England crowned the central tower at Lincoln Cathedral. Built of lead and wood, it reaches 160 metres (520 feet).

The Gothic 'revival'

The 19th Century saw a revival of interest in Gothic forms which triggered Gothic revival architecture, such as the Palace of Westminster and St Pancras station in London.

DIDYOU KNOW? Notre Dame was the first 'Temple of Reason' in which Robespierre's 'Supreme Being' was worshipped

A working church It is often forgotten that cathedrals are not just tourist hotspots, but also fully functioning working churches, their design echoing their use. Notre Dame is the metropolitan church of Paris - in other words, the seat of an archbishop. It houses the bishop's chair, called in Greek cathedra (hence 'cathedral'). The bishop's teaching ministry is exercised in collaboration with a college of canons known as the 'chapter'. The cathedral is not just the setting for services - the canonical hours and the daily sacrifice of the mass - but is also the mother church of a diocese (district) and a centre of pilgrimage. Copper rooster At the very top of the spire, the rooster holds three holy relics: part of the Crown of Thorns and two bones belonging to Saint Denis and Sainte Genevieve. Choir Containing wooden choir stalls, this is the space in which the cathedral canons meet daily to sing the canonical hours. Statue of St Mary The 14th-Century statue of 'Notre Dame de Paris' - 'Our Lady of Paris', to whom the cathedral is dedicated-stands at the entrance to the choir. Treasury This building houses all the liturgical vestments, vessels and precious objects used in the Double ambulatory cathedral's services. This semi-circular space, delineated by columns, is required for liturgical (public worship) processions. It surrounds the choir and sanctuary. Nave altar Double aisles



The view of Notre Dame from the Eiffel Tower



Stained glass manufacture

We know precisely how medieval coloured ('stained') glass was made, as in around 1125 a German monk named Theophilus wrote a Latin treatise called 'On Diverse Arts' in which the process of coloured glass manufacture was detailed. The essential material for glass manufacture was river sand (silica). Requiring a very high temperature to become molten, potash was added to allow the silica to melt. Other substances (lime) were then added to make the glass more stable. Glass was coloured by adding metallic oxides while it was in a molten state. Copper produced green, cobalt made blue and gold produced red or ruby glass. Glass coloured while in the clay pot in the furnace is known as 'pot metal' glass. Details of faces, hair and hands were painted onto the inner surface of the glass with special glass paint, made from finely ground lead or copper filings and ground glass, suspended in a medium such as wine or (traditionally) urine.



Notre Dame closed

Double aisles are found in a

number of early churches in

Rome, which emphasises the

dignity and importance of the

church as well as providing extra space for processions.

Revolutionaries close the cathedral and destroy the majority of the medieval interior, targeting statues, altars, woodwork and stained glass.



Coronation of Napoleon
Napoleon Bonaparte and his wife
Josephine are crowned Emperor
and Empress of France, with Pope
Pius VII officiating.

9081

Notre Dame receives the Crown of Thorns

Napoleon gives the cathedral the relic of Christ's Crown of Thorns. It is still exhibited to the public on the first Friday of the month.



The Bastille

The Bastille

Stormed during the opening days of the French Revolution, the Bastille epitomised the power of France's ruling Bourbon monarchy



The Bastille was originally built by Charles V, as a fortified gate to the Paris city walls in the mid-14th

Century. It was originally intended to aid the defence of Paris from English attack, as hostilities between the nations were at a heightened peak. However, by the 17th Century, the gate had been transformed into a full-blown military fortified armoury and prison, used by the French monarchy and nobility to detain political troublemakers and convicts.

Holding on average 40 enemies of state at any one time, the prison became synonymous for the state's authority and fascism, with people interned by a simple lettre de cachet (a direct arrest warrant that could not be challenged), which was signed by the King. Further, under the reign of Louis XIV, the Bastille became a place of judicial detention, where the lieutenant de police could hold prisoners. It also became a storage facility for any prohibited books and pamphlets (usually political or religious) deemed undesirable by the state.

The structure of the Bastille focused around eight, 30m (98ft)-high towers, linked by massively reinforced stone

walls. The walls, which were 3m (10ft) thick at the base, were surrounded by a 24m (70ft)-wide moat, which itself was surrounded by a series of other smaller fortified walls and structures. The positioning and circular shaping of the towers not only vastly increased the defensive resistance of the Bastille but also gave the soldiers mounted on top great 360-degree vision, capable of viewing the interior courtyards and surrounding territory easily. The linked nature of the towers also allowed soldiers to move from tower to tower, without having to descend to ground level first.

The interior of the Bastille consisted of two main courtyards, offices, apartments for lower-status officers, a council chamber for interrogation, multiple armament stores, dungeons, cells, dwellings for turnkeys, a kitchen and a small chapel. Cells varied in type dramatically, ranging from dark dungeon rooms filled with rats and water through to spacious apartments with stoves, chairs and beds, up to cramped and supremely cold tower rooms, where moving freely was incredibly difficult. The type of room that a prisoner was interned in depended on their social class (nobility



were allowed the better rooms and even outside guests), amount of money and seriousness of crime committed.

Execution was handled in three main ways within the Bastille: hanging by the gallows, beheading by the axe, or burning at the stake. Nobles were the only class of person who had a say in how they died, given the chance to opt for beheading, which was seen as the proper way for them to be executed by the aristocracy. Interestingly, due to the vast public interest and attendance at beheadings, they were never scheduled on the same day as a theatre premier.

In general, the Bastille delivered a far greater level of comfort than most other prisons in use at the time. However, due to its housing of many political activists and enemies of the state, it became a symbol of the monarchy's decadent and fascist regime. This came to a head on 14 July 1789, when revolutionaries approached the Bastille in order to ask its governor, Bernard Rene Jourdan, to release the large amounts of arms contained within to aid their cause. Jourdan was evasive; angered by his seemingly pro-monarchy actions, the revolutionaries subsequently stormed and captured the Bastille.

Inside the Bastille

Armament ·

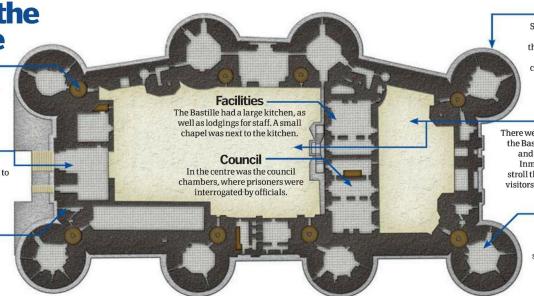
The Bastille was constantly stocked with armaments for use against prisoners, and in warfare if Paris was attacked.

Entrance

Originally there was more than one entrance to the Bastille. However, by the 18th Century it was only accessed by guarded drawbridge.

Apartments

Immediately to the right of the entrance were apartments for lower-status officers and, if class/money allowed, prisoners.



Dungeons
Sat under the bases of

the four towers were the Bastille's dungeon prisons. These were cold, damp, filthy and filled with rats and insects.

Courtyards

There were two courtyards in the Bastille, a large primary and a smaller secondary. Inmates were allowed to stroll the courts and receive visitors there if they wished.

Towers

The Bastille's eight towers were installed with spiral staircases and rooms on each floor. The topmost room was incredibly cramped and freezing cold. DID YOU KNOW? The Eiffel Tower was intended for Barcelona, but local officials refused the idea

The Eiffel Tower

Arguably one of the world's most recognisable landmarks, the Eiffel Tower is a celebration of science, engineering and art in unison

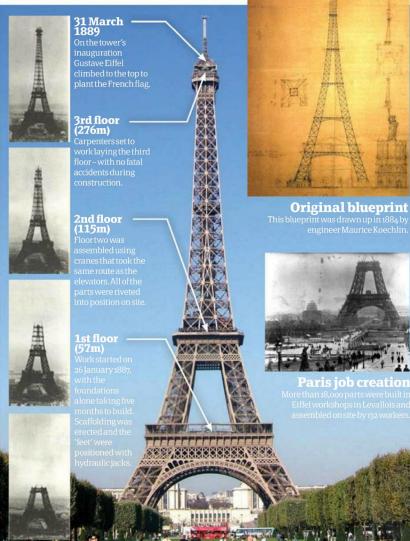


The Eiffel Tower was the brainchild of French structural engineer Alexandre

Gustave Eiffel, who proposed a 324m (986ft) tower for the capital's Champ de Mars, costing the city \$1.5 million, for its World's Fair.

Work began in July 1887 and took just under two years to complete. To begin with the framework was pre-assembled in a factory and in total over 300 workers joined 18,000 pieces of puddle iron to produce parts of the frame. When the parts were ready they were transported to the Champ de Mars where welders secured each segment in place. As the tower grew, moveable platforms were propped into place on the intermediary levels, not only to enable the workforce to weld the latticework together but for their own safety. The tower features exposed latticework and consists of two main parts; a 2.54-acre base which compromises a platform sitting upon four individual legs known as pylons or bents, and a tower created as the pylons incline towards each other. rising upwards past a second platform which then merges into one long column.

The shape of the tower was engineered using a mathematical calculation involving wind resistance. Eiffel reasoned that the tower had to counterbalance the wind pressure applied on any point by spreading the tension between the construction elements at that point. Therefore the tower's curvature revealed two exponentials: a lower base section that delivers stronger resistance to wind forces, meaning the tower will only sway at a maximum of 6-7cm in the wind.



History of the tower

The Eiffel Tower took just two years for 300 workers to complete and despite working on an open framework, and without the safety of intermediate floors, accidents were low and only one man died during construction. This is thought to have been due to the foresight of Eiffel who had insisted upon

safety precautions in the form of moveable stagings, guard rails and screens.

In 1909, at the end of its 20 year lease the tower came under criticism as an eyesore, and was almost torn down. It was only saved because of its antenna, which was used for the city's communications.



TALLEST VEHICULAR BRIDGE



1. The Millau Viaduct

Location: Spans the River Tarn near Millau, southern France Years constructed: 2001-2004 Architect: Michel Virogeux and Norman Foster Use: Four lane cable-stayed road bridge of the A75

Size: 343m high, 2,460m long Fact: With one of the mast summits reaching a height of 343 metres, the Viaduct is taller than the Eiffel Tower.

MOST SYMBOLIC

2. Statue of Liberty

Location: Liberty Island, New York, USA **Years constructed:** 1870-1886

Architect: Frederic Bartholdi **Use:** An gift to celebrate the independence of America **Size:** 305ft 6" tall and the base amasses 12 acres

Fact: Christened 'Liberty Enlightening the World', the statue was gifted by the French people to America for the centennial of the US Declaration of Independence.



3. The Pont du Gard

Location: Vers-Pont-du-Gard, south of France

Years constructed: 19BC Architect: Marcus Vipsanius Agrippa

Use: Aquaduct constructed during the rule of the Roman Empire to carry water from the Fontaines d'Eure springs to the Roman city of Nimes.

Size: 49m high and 275m long Fact: Today it is one of France's top five tourist attractions and was added to UNESCO's list of World Heritage Sites in 1985.



Tower Bridge

Tower Bridge

Discover how London's distinctive landmark uses suspension and bascule technology to bridge the River Thames



Work began on this extraordinary bridge in April 1886 and was planned to be

completed by 1889. Five years later than originally estimated, the bridge finally opened on 30 June 1894 at a cost of £1 million (approximately £100 million by today's standards). Many of the delays were caused by the requirement for the bridge to fit in with its surroundings and the sheer scale of the enterprise.

The bridge had to meet the needs of road traffic that wanted to cross the Thames and the demands of the river traffic. The solution was to construct a bascule bridge; this is from the French term for 'see-saw'. The bascules consist of two equal length sections that can be raised or lowered like drawbridges, from 65-metre tall towers built on piers on either side of the river.

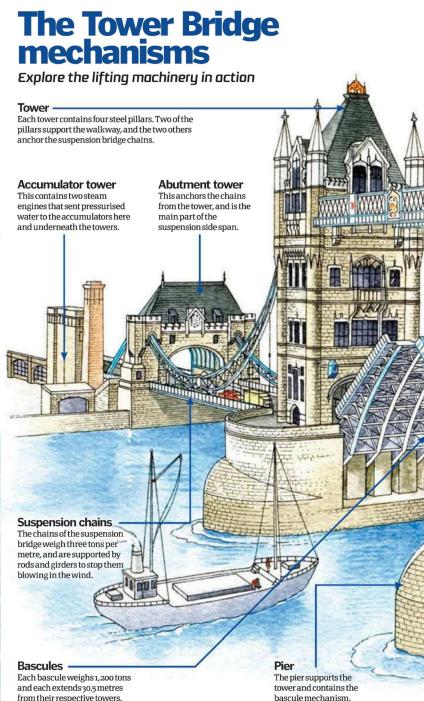


It was constructed with 14,000 tons of iron and steel girders and columns. To protect the steelwork and to echo the architecture of the nearby Tower of London, it was dressed with 35,000 cubic feet of Cornish granite and Portland stone, backed with brickwork. Altogether, 31 million bricks were used to build the bridge.

The piers supporting the towers were the first and most complicated task for the 432-strong construction gang, as they contain the equipment to operate the bascules. They had to position caissons (wrought iron boxes with no top or bottom) seven metres below the riverbed, that were welded together to form a hollow column. 12 caissons were needed for each pier and when finished they were filled with concrete. This slow process took four years and used 70,000 tons of concrete.

On the landside approaches to the towers, suspension road bridges were built that were anchored to the pedestrian walkways that span the towers. Each of the 82-metre long side spans carry chains from the main towers to their respective abutment towers.





Walkways

Competition

A competition was opened in 1876 to design the bridge, Out of 50 entries, the committee selected the entry by Horace Jones and John Wolfe-Barry, in October 1884.

Walkways

High-level walkways allow pedestrians to cross when the bridge is lifted. In 1910, they were closed because they attracted prostitutes and thieves.

Flypast

Stairway

A disgruntled RAF pilot flew his Hawker Hunter jet fighter aircraft underneath the top span of the bridge on 5 April 1968. He was immediately thrown out of the RAF.

Mistaken identity

When the old London Bridge was sold in 1968, to be shipped and rebuilt at Lake Havasu City, Arizona, it wa alleged the purchaser thought they bought Tower Bridge.

In numbers

A work crew could fit on average 200 rivets a day and 2 million were used throughout the whole structure. The bridge builders were paid £2 a week.

DIDYOUKNOW? A dining room for the bridge master was built inside the south abutment tower

Navigation control

Today, if you have a vessel with a nine-metre or higher mast or superstructure, you have to order a free bridge lift 24 hours in advance of your arrival. The bridge opens and closes approximately 1,000 times a year, and is operational every day of the year. VHF radio is used to keep shipping traffic in contact with the bridge control room, so that passing through the bridge is quick and efficient.

In the past, the bridge displayed red semaphore signals on the piers to control daytime shipping. At night, the piers showed two red lights to indicate the bridge was closed and two green lights if it was open. A gong was used if visibility was reduced. Ships planning to go through the bridge had to hoist a o.6m diameter black ball when travelling in daytime, or show two red lights at night.

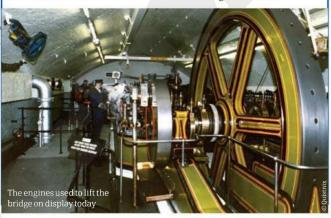


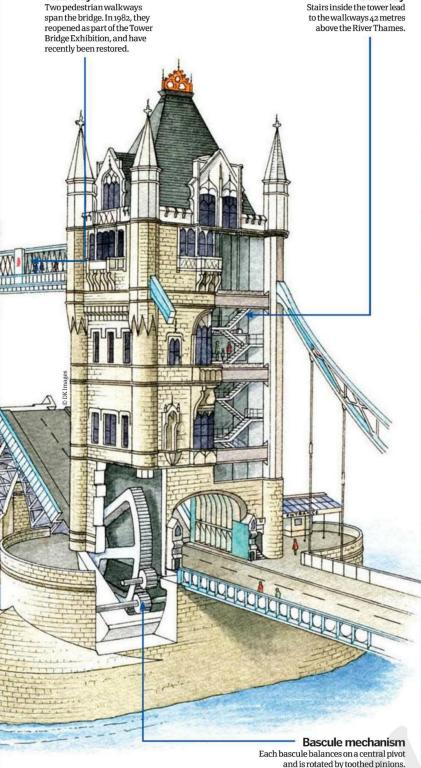
The lifting mechanism

The two sections of the bridge known as 'bascules' were originally lifted using two 360 horsepower steam-powered pumping engines. These engines pumped pressurised water to the accumulators, that stored it ready for use when the bridge bascules were needed to be lifted. Two of the accumulators were positioned in the accumulator tower and two were positioned inside each pier underneath the bridge towers.

The water power from the accumulators was sent to the driving engines that used hydraulics to lift the bascules. This complex mechanism enabled the bascules to reach an angle of 86 degrees in only one minute. Therefore, the whole process of opening and closing the bridge could take as little as five minutes.

Hydraulics are still used today, but the power now comes from electrical engines, and oil is used as the hydraulic fluid. The old accumulators, pumping engines and boilers can be viewed at the Tower Bridge Exhibition.



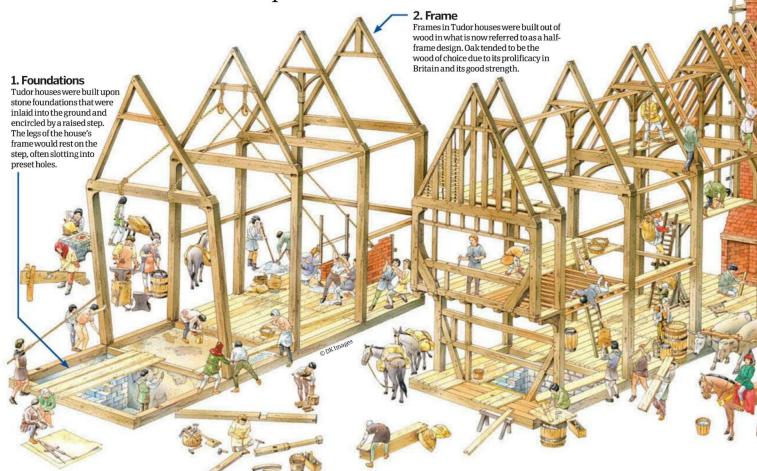




Tudor building construction

Tudor houses

Despite retaining the medieval taste for a Gothic style, the Tudors drove change in how houses were constructed through the late 15th and 16th Centuries. Find out how the process worked





Tudor houses were built following a half-timbered design. First, stone foundations were laid and encircled with a raised, hole-filled step into which

timber frames were slotted. The original frame was hoisted into place by manpower alone and then used as a lifting platform to pull up the next frame with ropes. The frames were typically made out of oak, as the wood was common in Britain at the time and strong considering how easy it was to cut by hand. Due to the beams being cut by the hands of human carpenters, they were often rather uneven and – as can be seen today – led to a slightly bumpy, off-kilter finish.

Second, the house's chimney was installed, which for the time was revolutionary. Before Tudor architecture became standard in the 16th Century, buildings tended to be heated using the 'great hall' design, where a single large room would house an open fire and disperse smoke through holes in the upper walls and roofing. This led to a heated but smoky main room and was impractical in anything other than hall-sized areas. The enclosed fireplace and chimney structure allowed Tudor houses to disperse smoke efficiently, allowing for smaller rooms to be heated. During this stage the first floor was boarded and stairs were installed, both made from wood, and the jetty support beams prepared.

Once the building's frame, chimney and floorboards were fitted, the gaps in the timber frames were filled with wattle panelling and then water/wind-proofed with daub. Wattle panelling is characterised by a latticework of thick wooden sticks interwoven to create a flat surface. Daub is a rather primitive form of plaster, made from a mix of wet soil, sand, clay, straw and animal dung. When combined, these completed the walls of the Tudor house.

The building was then roofed, either in thatch – which was common for secular buildings at the time – or crudely tiled, as well as having its windows installed. Glass creation in the Tudor period was

5 TOP FACTS TUDOR CONSTRUCTION 6,000

The wattle-and-daub used to build Tudor houses has been used for over 6,000 years as a building material all over the world, ranging from North America to Western Asia.

Wonky

The wooden frames used tended to be of oak, which was common in England at the time. They would often warp, leading to many original Tudor houses to appear wonky.

Herald

6. Windows

from wood.

As glass was still in its infancy as a material, large panes could not be created for Tudor houses. To create windows, multiple smaller pieces were held together with lead lattices and supported by dedicated wooden beams.

Window frames were also made

The Tudor house's adoption of modern chimneys and enclosed fireplaces heralded in the decline of the medieval staple of a great hall, a large room heated by an open fire.

ust

In Britain, most large-scale, original Tudor houses are owned by the National Trust, an organisation dedicated to maintaining the quality of the structures.

ung

One of the main ingredients of the daub glue material that covered the wattle lattice was animal dung, which was mixed in with wet soil, sand, clay and straw.

DIDYOU KNOW? Victorians coated Tudor houses' wooden beams with tar to make them waterproof

Building a Tudor house

3. Chimney

Replacing the medieval great hall system of dispersing smoke, Tudor houses introduced enclosed fireplaces and chimneys to channel the fire's smoke out of the building.

5. Daub

Daub is a sticky, binder substance made from wet soil, sand, clay, straw and animal dung, which Tudors used in conjunction with wattle panelling. The daub helped fix the wattle in place and provided a paste-like material to create wind/waterproof walls out of.



7. JettyDue to space considerations in cities, many Tudor houses were built with a jetty, which allowed the first floor to overhang the street below.

window frames. A good example of these changes can be seen in the oriel; this is an overhung, multi-sided window cantilevered out from either the building's first or second floor. Daub tended to be coated in an ochre-coloured pigment while the wooden beams of the building remained exposed.

branches. Tudor houses used wattle to fill the holes between

the timber frames. To

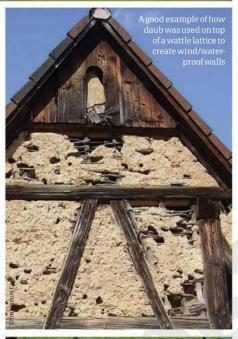
affix it in place it was

used with daub.

The archetypal tar black beams and whitewashed daub was not actually widespread during the Tudor period, but more a product of a movement of Victorian romanticisation of the Tudor period later in the 19th Century, with many traditional and mock houses being repainted to give them the effect we still often see today.

Little Moreton Hall, a 15th Century Tudor manor house located in Cheshire, England







primitive compared with today's modern standards and craftsmen were unable to create the necessary large single panes. Tudor windows were therefore constructed from numerous smaller panes which were held together in place by an iron latticework in a tall, thin frame. Due to the combined weight of iron lattice and thick glass, the wooden window frames needed to be supported by a dedicated wooden beam which was positioned underneath.

Finally, the external trim and decorations were completed, which due to the influence of the renaissance on 16th Century Britain, led to big changes in artwork, carvings, doors and also



The Taj Mahal

The Taj Mahal

A beautiful monument to his late wife, find out how the Mughal emperor built India's Taj Mahal



Three acres of land was carefully excavated for the foundations of the Taj Mahal, and

replaced with dirt and rubble to reduce seepage from the nearby river. In the area that was to house the tomb, deep wells were dug down to water level and later filled with stone to form the secure footings that would hold the building firmly in place. One well remained unfilled to track the water changes over time, but the rest of the 580m x 300m site was levelled to 50 metres (160ft) above the river bank.

A construction team of over 20,000 labourers was recruited from the north of the country to build the monument and included a creative contingent of 37 artisans who were disciplined in the arts of sculpting, calligraphy, inlaying, stone cutting, turret building and

marble art carving. Furthermore, over 1,000 elephants were used to transport the sourced materials from all over India and Asia. In order to transport the materials to the site a 9.3 mile (15k) ramp of tampered earth was carved into the land allowing smoother access for the teams of up to 30 oxen and mules that were used to heave the blocks of marble on specially designed wagons.

It was typical at this time to use bamboo scaffolding for the workers to construct buildings, but for this project the architects fashioned a revolutionary brick-based framework, favoured for its longevity and rigidity. To elevate the blocks into position a post and beam pulley system was employed; to hoist two upright marble posts to hold a marble beam horizontally across the top, resulting in a free-standing framework which was gradually extended.

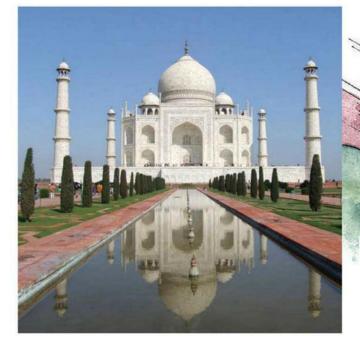
Water supply

Drawn from the riverbed by a series of purs (an animal-powered rope and bucket mechanism), water was deposited into a large storage tank; from this over a dozen other purs raise the liquid to a large distribution tank above the ground. The water flowed from the tank to three subsidiary containers and was

piped into the complex. A pipe hidden 1.5m underground travelled parallel to the main walkway, filling the main pools of the garden. Extra copper pipes were utilised to disperse the water to the fountains in the north-south canal and subsidiary channels were created to irrigate the rest of the grounds.

Dome

The marbled dome roof of the tomb is 35m and is known as the onion dome. The iconic dome sits on a 7m cylindrical tower to accentuate its height.



Minarets

Four minarets are pinned around the tomb, just off each corner of the square plinth, used by the muezzin to call the Islamic people to prayer.

The main focus

The most obvious and central focus of the Taj Mahal is the tomb. Constructed of white marble, the symmetrical building stands on a square plinth and features a prominent arched doorway, domed roof and finial.

Gateway (not shown)

The marble gateway's arch mirrors the shape of the tomb's and features vaulted ceiling and walls exhibiting elaborate geometric designs, mimicking those found inside more of the complex's sandstone buildings.

The tomb

The tomb is a multichambered cube with chamfered corners to form an unequal octagon approximately 55 metres on each of the four longest sides

Head to Head ARTISTIC TREASURES



1. Temple of Hatshepsut Three tiered mortuary temple dedicated to Hatshepsut, the ifth pharaoh of the eighteenth

dynasty of Ancient Egypt.



of Jam The 65m tall structure played an important role in the

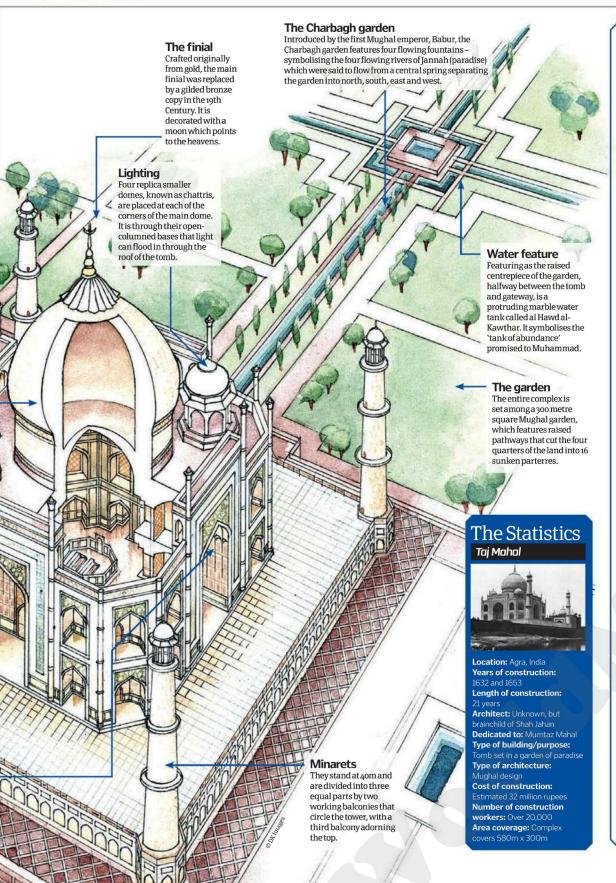
in the Indian sub-continent



3. Thracian Tomb of Sveshtari

A 3rd Century tomb reflecting the architectural principles of Thracian cult buildings from the culture of the Getae

DIDYOU KNOW? When translated, the name Taj Mahal means 'crown palace'



Why was it built?

While the country was enjoying great prosperity in 1631, Mughal emperor Shah Jahan was grief stricken by the death of his third wife Mumtaz Mahal, who had died during the birth of their fourteenth child. Built in loving memory of Mumtaz, work began on the Taj Mahal in 1632 and ended in 1653 in an unused area in the south of the walled city of Agra, India. The emperor divided the grounds into four distinct sections: the Taj gateway, the Taj garden (Charbagh), the tomb and the Pietra Dura (the crypt and cenotaphs).

Design inside nd out

The building features what is considered the best example of Mughal design; a fashion which fused the styles of Persian, Indian and Islamic architecture of the time. However, Shah Jahan broke with tradition in a bid to reach unprecedented levels of sophistication by using vast quantities of white marble inlaid with semi-precious stones, instead of the more traditional red sandstone. Employing a fleet of mules, oxon and elephants Shah Jahan imported white marble from Rajasthan, jade and crystal from China, jasper from Punjab, turquoise from Tibet, lapis lazuli from Afghanistan, sapphire from Sri Lanka and carnelian for Arabia.

The tomb is enclosed in a garden of fountains, segmented flowerbeds and ornamental trees and the entire complex was intended to be riddled with reflections, symmetry, symbolism and hierarchy to emphasis the key elements of the property. In total the plinth took 12 years to finish, whereas the minarets, mosque and jawab, and finally the gateway, took an extra decade.



Great Wall of China

The Great Wall of China

The Great Wall of China is the longest man-made structure on Earth

Contrary to popular belief you cannot actually see the Great Wall of China from the moon. According to scientists, trying to view the Great Wall from the moon would be the equivalent of a human trying to see a single strand of hair from a distance of two miles. In fact, while we are busting myths, neither is the Great Wall a single continuous structure, but rather a succession of independent walls and fortifications built over successive Chinese dynasties.

Built originally by the first emperor of unified China Qin Shi Huangdi in order to keep out the nomadic Xiongnu tribes inhabiting Mongolia, the Great Wall was designed to be the first line of defence for the Chinese people against any aggressive raids and attacks. Stretching originally along the newly founded northern frontier of the

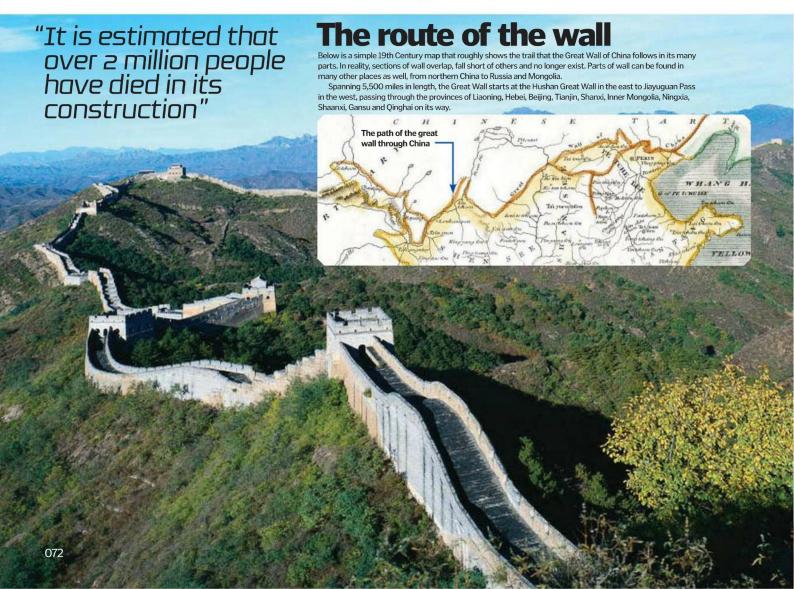
country – before being expanded and rebuilt by following emperors until it spanned piecemeal from Qinhuangdao in the east to Jiayuguan in the west – the Great Wall was a massive undertaking for the soldiers and civilians who were tasked with its construction.

The Great Wall was built originally from whatever was local to the specific area, such as wood, earth and stones, as transferring large quantities of materials from elsewhere was a very costly and laborious task. Later rulers of China, however, used much stronger materials including bricks, tiles and stone to build the wall, allowing for more resilient and much tougher fortifications and battlements. In order to build such a long and deep wall (some sections of the Great Wall are as much as six metres wide at the base and it is roughly 5,500 miles long),

over half a million labourers and 300,000 soldiers were required to build the Qin section, a number only to rise with the additions of subsequent emperors. It is estimated that over 2 million people have died in its construction.

The Great Wall of China was defended primarily by archers that, due to the inability of attackers to bring horses over it, left potential attackers on foot with only the option of scaling it. This allowed for the wall to remain relatively unmanned in terms of military might, with small groups of soldiers patrolling large sections.

Despite its grand appearance however, the Great wall was never supposed to keep out a fully fledged army who if determined could actually breach it quite easily, but rather to prevent flash raids from smaller groups.



Head to Head THINGS THAT LEAN



Frankenhausen

The church's spire inclines to ne side. Leaning at 4.5 degrees the tilt is increasing at a rate of six centimetres



2. The bell tower, at the church of San Nicola

Thought to be the product of the same architects, the bell tower of San Nicola is also tilting with the base currently secured.



3. Leaning Tower of Suurhusen

This late medieval steeple in East Frisia, Germany is the most tilted tower in the world according to the Guinness Book

DIDYOUKNOW? The name Pisa originates from the Greek word for 'marsh land'

Leaning **Towe**

Find out how the tower was made and how it went wrong...



The local architects and city officials designed the complex at Piazza dei Miracoli (the Square of Miracles) as a

dedication to art, and as such it is thought the principles of science and engineering were not fully understood.

The tower was built in three stages over a period stretching nearly two centuries. The first part of the tower was built during a time of town prosperity and as such heavy white marble was used for the base and tower, with limestone used for the interior and exterior design features.

Disaster occurred just five years after work began, as the workers finalised the interior of the third floor. The tower was sinking because the weight of the marble building was too much for the extremely insufficient three-metre foundations which had been set in weak and unstable soil that contained a malleable mixture of clay, sand and rubble. The construction was halted for nearly a century to allow the soil to settle. In 1272 work recommenced as engineers began to build the tower's middle section. To compensate for the continuing problem of its lean, the workers built one side of the wall taller than the other. Subsequently the tower began to lean in the opposite direction and caused it to curve. War caused a break in construction and the seventh floor was not completed until 1319 and the eighth level, featuring the belfry, was finally added in 1372.

First floor interior

Lining the inside the first floor is a series of arches in a typical Romanesque blind arcade style, intersected with columns displaying classical Corinthian capitals.

Foundations

Made of white marble the construction began in 1173 during a time of prosperity in Pisa thanks to the success of its military.



Bell tower

The Bell chamber was added in 1372. It features seven bells -one for each note of the musical scale. The largest of which was installed in 1655.

Shape

The tower has a cylindrical body encircled with arches and columns. The central body is a hollow shell which features an external wall of white and grey limestone.

Spiral staircase

The inner wall was fashioned from worked limestone and comprises a 296-step spiral staircase.

Curvature

In 1272 architects fashioned a corrective axial inclination where the walls on one side of the tower were taller than the other-giving the building its concave appearance.

Third floor

Upon reaching this level, engineers noticed the tower was starting to sink. The heavy white marble had become too heavy for the foundations set in soil.



The Statistics

Leaning Tower of Pisa

Location:

City of Pisa, Tuscany, Italy Years of construction:

Length of construction:

Architect: There is still original architect but the Guglielmo and Bonanno Pisano, Height - both high side / low side: The original height Type of building/purpose: Angle of lean: 3.97 degrees Weight of the tower: Number of steps: 296

How to stop the tower toppling...

In 1964 a desperate Italian Government requested aid to stop the tower from toppling. One of the first methods to be tested was to add 800 tons of lead counterweights to the raised end of the base, but this only added to its subsidence. With the problem worsening it was decided to close the tower in 1990 and remove the bells to relieve some of the weight.

Cables were cinched around the third level and grounded several hundred metres away to anchor the weight. Work began on removing some 38 cubic tons of soil from under the raised end of the base, which straightened the tower by 18 inchesregaining an angle last recorded in 1838. Ten years of corrective stabilisation followed and the tower reopened to the public in 2001. In 2008 another 70 tons of earth was excavated and for the first time the structure has officially stopped moving.



Venice



How Venice was built

How was the much-loved Italian city constructed on top of marshland?



Despite Venice being frequently voted the world's most beautiful city, on paper it appears to be a logistical and constructional nightmare. It is built,

largely, on marshland – a lagoon which is just 8 per cent land, and one that contains some of the largest and heaviest religious and administrative buildings in Italy. And that's not even accounting for the dwellings of an estimated 60,000 residents and the risk (a very real risk as shown by history) of cataclysmic flooding. This, of course, raises the question: how does Venice keep above the water?

Key to its construction is an ancient method of using raised foundations, which effectively elevate ground zero to a height where buildings can be safeguarded from tidal waters. This involves the hammering of thousands of pilings – large wooden stakes commonly made from alder – through the water and into the underlying sand and clay. Each piling is positioned very closely to its neighbouring stake, one after the other, ultimately forming a raised wooden platform. Once a certain number of pilings has been driven into the earth, the tops are evened off and a substrate (or foundation layer) of wood and marble laid over the top. It is upon this which Venice's buildings are constructed.

Of course, raising buildings out of the water is but one half of building in Venice - the other being to successfully channel the lagoon's waters into commutable highways. Venice's canals, which run for a total of 42 kilometres (26 miles), are built and maintained in a multi-stage - and never-ending process that begins with the construction of a cofferdam. A cofferdam is a temporary barricade that, once erected, allows a portion of the lagoon's waters to be blocked and redirected, which is necessary for any building work to take place. Once the damming structure is in place, the draining of the area can start, with industrial pumps removing any remaining water held in the channel. Next, large-scale dredging takes place, with huge diggers and cranes excavating the channel.

Once the channel is clear, engineers can begin fortification of the canal, utilising pilings, bricks, clay and – more frequently in recent years – cement to line and strengthen its core structure. Wooden pilings are still used today because, when submerged, the almost zero-oxygen environment of the canal preserves them incredibly well, as well as bolstering their strength further through

petrification – an effect caused by the flow of mineral-rich waters in their immediate vicinity.

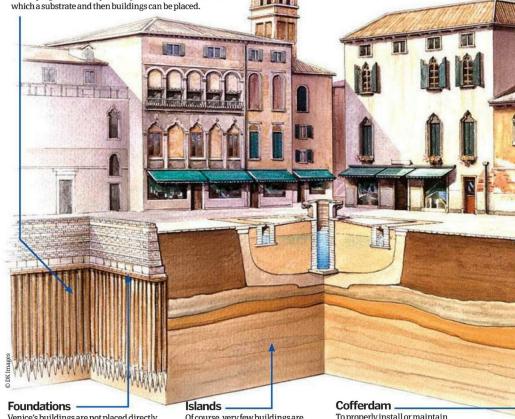
Finally, and most topically, Venice's construction is protected by a series of flood-prevention mechanisms. These range from the installation of conventional concrete dams around the city, through to a project initiated in 2003 (MOSE) to set up huge inflatable pontoons at the mouth of the lagoon when high waters threaten.

Pilings

Large wooden columns driven into the water and underlying sand and clay. These provide a stable base onto which a substrate and then buildings can be placed.

The floating city explained

Breaking down the materials, tools and techniques required to build and maintain a city on water



Venice's buildings are not placed directly onto pilings but rather a dual-layer substrate made from, firstly, planks of wood and, secondly, thick sheets of marble – the latter being water resistant. Of course, very few buildings are built solely on pilings alone, with the Venetian Lagoon containing 117 small islands atop, or off of, which the majority of structures are assembled. To properly install or maintain existing pilings, as well as the canal walls themselves, engineers erect temporary dams called cofferdams in order to cut off/divert water flow.

Islands

Venice spans across 117 small islands in the marshy Venetian Lagoon of the Adriatic Sea. The lagoon itself stretches between the mouths of the Po and Piave rivers.

Plague

2 Between the mid-14th and early-17th centuries, Venice was hit by the plague no less than three times, with the 'black death' claiming more than 200,000 lives.

Sinking feeling

3 In the 20th century Venice began to sink, caused largely by the digging of many artesian wells in the vicinity. As a result, artesian wells were banned in the Sixties.

MOSE

In 2003 the Italian government initiated the MOSE project, which involves the creation of 79 inflatable pontoons across the entrance to the lagoon to reduce the risk of flooding.

Tourist hotspot

5 Venice is one of the most visited cities in the world, with a recent estimate stating over 50,000 tourists arrive daily. This number increases further during the famous carnival.

DIDYOU KNOW? Venice's name is derived from the ancient Veneti people of the 10th century BCE





The Roman Colosseum

Inside the Colosseum

The Colosseum was the icing on the lavishly decorated Roman Empire, and still stands as one of the most iconic thumbprints of Imperial Rome



Unlike many other amphitheatres, the Colosseum was constructed in the city centre, placing

it as the literal and symbolical heart of Rome.

Originally the construction was called the Amphitheatrum Flavium deriving from the Flavian dynasty, as it was built during the reign of Vespasian between AD 70 and 72 on land that Nero had seized following the mass destruction caused by the Great Fire of Rome in AD 64, which he used to create his own personal haven, the Domus Aurea. Vespasian's decision to build the Colosseum on the site of Nero's lake and gardens was interpreted as returning the land back to the citizens of Rome.

Work on the stadium had been completed up to the third storey at the time of Vespasian's death, with the upper level completed under his son Titus's reign. The gallery at the top and the hypogeum (a series of underground tunnels used to hold slaves and animals) were added years later by Emperor Domitian, Titus's brother.

Its capacity stood at approximately 50,000 spectators and was used for gladiatorial combat, games and other public spectacles. In the medieval era it was no longer used for entertainment but rented out for housing, storage and religious premises until the 12th Century at which point the Frangipani family

fortified the exterior and used it as a castle. A religious order moved in mid-14th Century, and inhabited the site until the early 19th Century.

Today it stands as a battered relic of the monument it once was. It was first devastated by fire in 217 and earthquakes in 443 and 1349 caused more damage. Over the last few hundred years the interior has been stripped of stone, the marble facades burned to produce quicklime and the bronze clamps which secured the stonework have been hacked out of the walls, scarring the face of the building.

Entrance and exit

Like many of today's football and rugby stadiums it was pocketed by 80 numbered entrances and exits ideal for quick evacuation and entrance, 76 were used by the public. The northern main entrance was for the Emperor, and the three remaining for the elite.



Hypogeum

Today a wooden walkway runs over the hypogeum (underground), which would have originally been concealed by an arena wall. The substructure was partially excavated in 1810-14 and fully exposed under Benito Mussolini in the Thirties. Today the hypogeum remains unveiled and consists of a two-level subterranean network of tunnels and caves beneath which slaves, gladiators and animals were held before the contests.



What's in a name

The name 'Colosseum' is believed to have derived from a bronze statue of Nero, erected nearby. It was later remodelled into the likeness of Helios/ Apollo the Sun god.

Size

The elliptical stadium is 189 metres (615 feet) long and 156 metres (510 feet) wide with a base area of an impressive 24,000 metres squared (six acres).

Wonder of the world

On 7 July 2007 the Colosseum was voted as one of the New Open World Corporation's New Seven Wonders of the World (along with the likes of the Taj Mahal, and Petra).

Some gladiators were burly volunteers, likely to have been former

soldiers who risked their social standing in pursuit of popular

acclaim and public admiration. However, most were slaves or

persecuted Christians, who had no choice in their participation.

As well as mortal combat, gladiators would fight animals in shows

known as venatio, and would depict the fighter hunting a variety

of beasts imported from Africa and the Middle East.

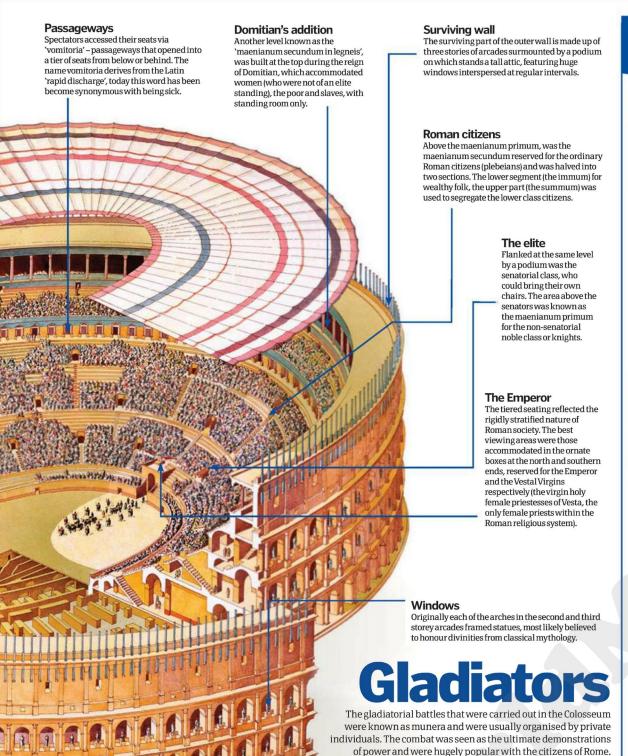
Anti capital punishment

In irony of its bloody heritage, the site stands as a symbol of the anti-death penalty movement after a demonstration took place there in 2000.

Velarium

The Velarium was a popular Roman invention that was used inside the Colosseum as an awning to protect against any rain and to provide shade.

DIDYOUKNOW? Not everyone was welcome at the Colosseum. Those excluded were former gladiators and actors



Head to Head AMPHITHEATRES



1. Flavian Amphitheatre of Pozzuoli

Location: Pozzuoli, Italy **Built:** During the reign of emperor Vespasian, between AD 69 and AD 79

Capacity: 20,000
Design features: The
construction is one of two
surviving amphitheatres in
Pozzuoli, the smaller and older has
almost been completely destroyed
by the creation of the RomeNaples railway line.
Fact: Thought to be designed by

Fact: Thought to be designed by the same architects associated with the Colosseum.



2. Theatre of Dionysus

Location: Athens, Greece Built: 325 BC Capacity: 14-17,000 Design features: Built at the foot of the Acropolis. Fact: The restored amphitheatre will include both modern additions as well as restored surviving elements such as the marble seats.



3. Pula Arena

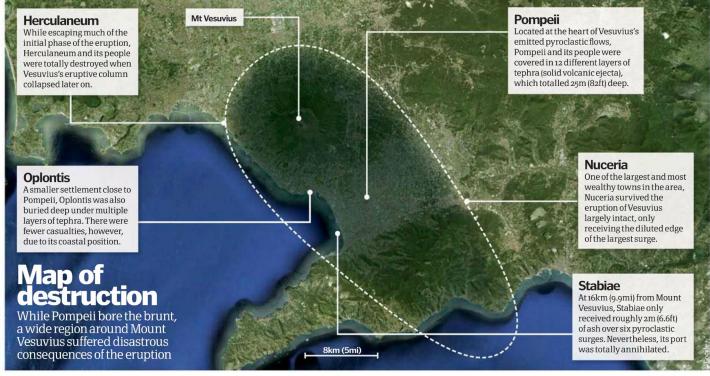
Location: Pula, Croatia Built: 27 BC-AD 68 Capacity: 23,000 (one of the six largest surviving Roman arenas)

Design features: An outside ringed wall of limestone. The section that confronts the sea exhibits a three-storey design with the other side featuring as it's on a slope.

Fact: The building was pictured on the reverse of the Croatian ten kuna bank note, last issued in 2004.



Pompeii



The destruction of Pompeii

When Mount Vesuvius erupted in 79 CE, it wiped the city of Pompeii off the face of the planet, burying both it and its citizens under tons of volcanic fallout



Pompeii was a medium-sized Roman city in the Italian region of Campania. In 79 CE, however, it was completely destroyed in the eruption of nearby Mount Vesuvius, a

stratovolcano located close to the city of Naples.

The destruction of Pompeii (and other cities; see 'Map of destruction') was caused according to stratigraphic studies in two main phases. The first phase was a Plinian eruption, which is typified by a colossal ejection of gas and volcanic ash high into the stratosphere. This phase lasted roughly 20 hours and produced a rain of pumice in a southwards-reaching cone that stretched for over 32 kilometres (20 miles).

The second – and for the people of Pompeii, even more deadly – phase was a Peléan eruption, which consisted of a number of vast pyroclastic flows. These flows were fast-moving currents of superheated gas (at roughly 1,000 degrees Celsius/1,800 degrees Fahrenheit) and rock that rapidly dispersed at ground level into the surrounding area. The combination of both these phases led to the burning and asphyxiation of all life that stood in harm's way.

In addition, the eruption caused a small tsunami in the nearby Bay of Naples, rendering escape attempts by boat impossible, and a series of tremors that aided the destruction of dwellings and temples.

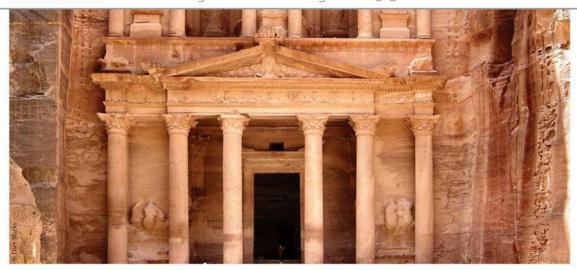
Today, over a thousand casts have been made from impressions of bodies trapped in Vesuvius's ash and flow deposits discovered in and around Pompeii, along with various other scattered remains. Out of the

total found, 38 per cent were discovered in ash fall, with the remaining 62 per cent found in surge deposits. Unfortunately, due to a lack of official documentation from the time, what percentage these represent of Pompeii's total population is unknown.

Since the eruption of 79 CE, Mount Vesuvius has erupted more than 30 times, the last occurring in March 1944. Despite this, the area surrounding Mount Vesuvius continues to be lived in by many Italians, with the entire region in its immediate vicinity colonised. To combat the potential for disaster, the Italian government foresees the need for an emergency evacuation of over 600,000 people and has marked a 'Red Zone' for those areas that would be most severely affected.







The Statistics

Petro

Location: Petra is situated in the Jordanian governorate of Ma`an. It lies on the slope of Mount Hor. **Length of construction:**

Building began around the 6t Century BC, but dates and building phases are largely unknown.

Function: Petra was a capital city of the Nabataens. It was a major trading site.

Architecture: The ancient Egyptians, the Greeks and the Romans had enormous influence on the architecture of Petra.

Rule: In 106 BC Petra became a part of the Roman Empire.

Almost a century later, the trade routes vanished and the city went into decline.

Size: Petra is built within a large area of open land that is first approached by a gateway to the Siq, a narrow winding path flanked by tall rocks and crags. From here you can catch a first glimpse of Petra in the form of the 40-metre high treasury facade. The treasury is surrounded by more than 800 monuments.

Petra: the rose red city

From the time of its modern discovery in 1812, Petra has been immortalised by artists, poets and filmmakers



The capital city of Petra (which means `rock`) lies in a natural basin that accessed water through a permanent tract. The area was

prone to flooding and the city dwellers used dams, wells, cisterns and water conduits to direct and store water. The Nabataens (the inhabitants of Petra) lived in a natural oasis and enjoyed great prosperity. Some of their buildings were free-standing while others were carved from the natural rock. The Nabataens used sandstone to create complex structures such as vaults, domes and

The buildings carved into the rocks

arches. The stone was cut from a local quarry and transported to the site by a sledge that was dragged over rollers. The Nabataens also used luxury materials such as juniper and olive wood, marble and limestone.

During the building process the craftsmen used pulleys, ladders and ropes to carve their monuments. Working from top to bottom they used picks, hammers and claw chisels on the outer surfaces. Influenced by the craftsmen of Alexandria, the Nabataens created a complex city compound that included houses, tombs, a treasury and an amphitheatre.

Life at Petra

Petra was built on an important point on the trading route between Asia and Arabia. Because of this. Petra was a cosmopolitan and cultivated city that was well sustained by commerce, agriculture and water. The population, believed to have been about 20,000 people, was familiar with foreign migrants, their crafts and trading goods. Artistic merit is visible in the decoration of the elaborate buildings and tombs.

Keeping Petra safe

The Petra National Trust was established in 1989. Its aim is to protect this World Heritage Site. Petra is now recognised as one of the world's most endangered archaeological centres. Not only is it damaged by flooding and salt erosion, but also by tourism. Planes and helicopters, once used for aerial tours, threatened the stability of the area. Thanks to the work of the Trust they have now been banned. The Trust deals with issues that concern the local inhabitants who use the site as homes, storehouses and stables.



The White House

For more than 200 years, this famous building has been the home of the presidents of the United States



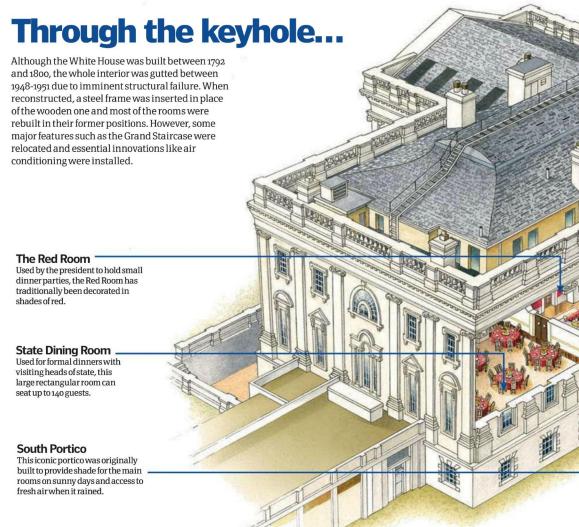
A symbol of the presidency, the United States government and the American people,

construction of the White House began in October 1792. Two years previously, President Washington, together with city planner Pierre L'Enfant, chose the site for the new presidential residence – the official address of which is now 1,600 Pennsylvania Avenue.

As preparations began for the new federal city, an architectural competition was held to find a design for the 'President's House'. Nine proposals were submitted and Irish-born architect James Hoban won a gold medal for his practical and elegant design. Aside from the colonnades which link it to the East and West Wings, the White House has changed little in its appearance since its completion.

Although President Washington oversaw the construction of the house, he never actually lived in it. It was not until 1800, when the White House was nearly finished, that its first residents – President John Adams and his wife – moved in. It survived a fire at the hands of the British in 1814 (during the War of 1812) and another fire in the West Wing in 1929, while President Hoover was in office.

Throughout much of Harry Truman's presidency, the interior of the house was completely gutted and renovated, although the exterior stone walls, first put in place when the White House was constructed two centuries ago, were left in place. Since its completion in 1800, each president has made his own changes and additions to the house, tailoring it to their specific needs and tastes. Presidents can express their individual style in how they decorate some rooms and in how they receive the public during their stay.



The West Wing

The West Wing houses the president's office (the Oval Office) and those of his senior staff. With room for about 50 employees, the wing also includes the Cabinet Room and the White House Situation Room. Built in 1901 due to overcrowding in the main house, the West Wing was damaged by fire in 1929, shortly after which a second storey was added. President William Howard Taft (1909-1913) engaged Nathan C Wyeth to extend the West Wing, which included the addition of the Oval Office. President Franklin Roosevelt (1933-1945) had the Oval Office moved to its present location, by the Rose Garden, during his tenure.

The name

It has been known as the President's Palace, the President's House and the Executive Mansion. Roosevelt christened it the White House in 1901.

The size

Looks can be deceptive - although the White House doesn't appear particularly large, it contains 132 rooms, 35 of which are bathrooms, spread over six floors.

The facilities

The White House has a variety of recreation facilities. These include a tennis court, jogging track, swimming pool, a bowling lane and private cinema among others.

The colour

As its name implies, the White House is white and requires regular re-painting to keep it looking fresh. Over 570 gallons of paint are needed to cover its exterior surface.

Instantly recognisable

Known throughout the world, the White House appears on the reverse of the \$20 bill and has been blown up in countless films, such as Independence Day.

DIDYOUKNOW? The White House is the only private residence of a head of state that's open to the public free of charge

The Lincoln Bedroom

Named after President Abraham Lincoln, this bedroom contains a bed purchased by Lincoln's wife and which has been slept in by a number of American presidents.

The East Wing

The Green Room

namesake colour.

The Blue Room

small dinners.

Used for small receptions and teas,

cocktails are served here before

and it is painted in shades of its

Commonly mistaken for the Oval

Office, the Blue Room is used for

receptions, receiving lines and

state dinners. The floor was originally covered in green canvas

 $The \ East \ Wing, which \ contains \ additional \ of fice \ space, was \ added \ in \ 1942. \ Among \ its \ uses, the \ East \ was \ added \ in \ 1942.$ Wing has intermittently housed the offices and staff of the president's wife (the first lady) and the White House Social Office. In 1977, Rosalynn Carter was the first to place her personal office in the East Wing and to formally call it the Office of the First Lady. Although extra office space at the White House had been needed for some time, the East Wing was built during WWII to hide the construction of an emergency underground bunker. This bunker has come to be known as the Presidential Emergency Operations Center (PEOC); it is said to have been designed to withstand 50 nuclear blasts.



the Vermeil Room houses a collection of silver and portraits of American first ladies.

Below: the Oval Office: Bottom: interior shell of the White House during a renovation in 1950



The Latrobe White House

The architect Benjamin Latrobe made many additions to the original White House design, but most were destroyed in the fire of 1814

Entrance hall and state rooms Most of Latrobe's drastic alterations to the interior of

the White House were never actually undertaken.

Interior decoration 2 Interior decordant Latrobe designed furniture and decorations, which were introduced to the house although all were decimated during the 1814 fire.

Water closets Latrobe introduced toilets to the White House, missing from the original design.

Grand Staircase 4 Grand Stan Sas Latrobe installed this staircase. It was rebuilt after the fire of 1814, but moved during President Truman's reconstruction of the interior.

West Colonnade Built to house the White House laundry and storage.

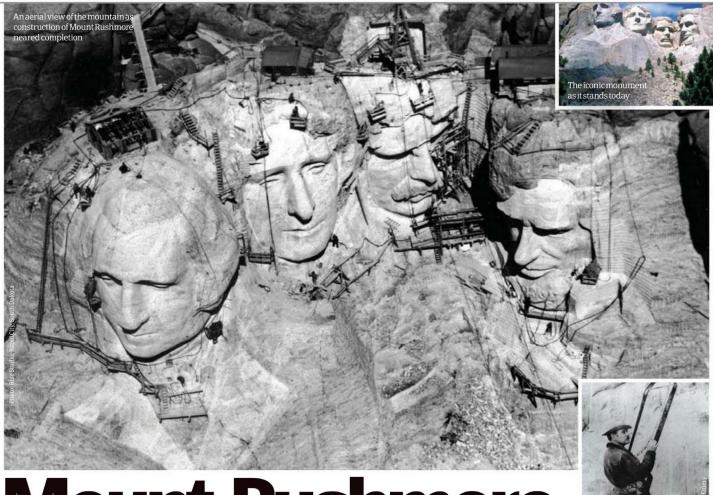
East ColonnadeBuilt to house the White House stable block

Executive Residence

 $The \, Executive \, Residence \, stands \, between \, the \, East \, and \, West \, Wings, \\ linked \, by \, the \, determined \, the \, de$ East and West colonnades. It houses the president's private rooms (ie his home), as well as state rooms for ceremonies and official entertaining. The four main $floors\,consist\,of\,the\,ground\,floor,\,which\,includes\,the\,Diplomatic\,Reception\,Room,$ Vermeil Room, the main kitchen and other offices; the State Floor, which contains the Green Room, Blue Room, Red Room, State Dining Room and Grand Staircase; the second floor is the family residence including bedrooms etc; while the third floor contains a solarium and a games room.



Mount Rushmore



Mount Rushmore

How were these stony-faced presidents carved into the granite?



The ultimate symbol of American democracy, the Mount Rushmore National Memorial has presided over

the Black Hills of South Dakota since its completion in 1941. The sculpture, depicting 60-foot effigies of presidents George Washington, Thomas Jefferson, Theodore Roosevelt and Abraham Lincoln, was designed by sculptor Gutzon Borglum, who passed away before the memorial was finished.

On a happier note, of the 400 workers involved in carving these iconic figureheads, none died during the mammoth undertaking – unusual for any construction of the time, let alone one involving dynamite and at such dangerous heights. In fact these workers even had to climb a mountain to get to work, but then this was during America's Great Depression, a time when a lot of people were just thankful to have jobs.

A massive 90 per cent of the rock removed from the mountain was blown away using dynamite. The powdermen in charge of the explosives set different-sized charges in specific locations in order to remove exact amounts of rock.

So that's the main structural sculpting taken care of, now for the less explosive techniques. Men were lowered down in front of the 500-foot rock face in bosun's chairs, using thick steel cable. At the top of the mountain men in winch houses controlled and lowered the cables by hand. If they winched too quickly, the workers in the bosun's chairs would be injured, and so call boys were employed to sit on the mountain edge and shout instructions to the winch men.

To sculpt the last six inches of stone, drillers and carving assistants used jackhammers and a technique called honeycombing, whereby they bored holes very close together. This weakened the hard granite so that it could be finished off by hand and then the presidents' faces were smoothed off using 'bumping' tools. Gutzon Borglum inspects the work on the memorial from a bosun's chair. These were suspended from above with steel cables, while workers drilled into the granite with jackhammers.



The Statue of Liberty

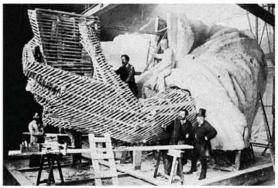
The Statue of Liberty was officially titled 'Liberty Enlightening the World'. It was built as a monument commemorating the centenary of the Declaration of Independence



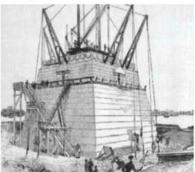
Constructed by the French, the Statue of Liberty was designed as a colossal copper statue. Gustave Eiffel, the designer of the Eiffel Tower, was asked to build a massive iron pylon and a skeletal

framework to act as the support for the sculpture. While remaining fixed to its steel frame, the structure was able to move in the wind - subsequently, wind speeds of 50 miles per hour have been recorded, and the statue has been known to sway up to three inches under pressure.

The pedestal, crafted from Scottish sandstone, was built in the USA. Once this was erected, it was time to assemble the statue proper. Parts of the statue were shipped from France. They arrived in 350 pieces and were packed into 214 crates. It took four months to assemble the statue and secure it on the pedestal. The pedestal is supported by two sets of iron girders which are connected by iron tie beams - these extend upwards into the framework of the statue creating a strong link from the ground. The Statue of Liberty was originally designed as a lighthouse and functioned as such from 1886 to 1902. It housed an electric light that could be seen several miles out to sea.



The construction process began by



The Statistics

Statue of Liberty

Sculptor: Frederic Batholdi Year built: 1879-1884 Purpose: The statue was a commemorative gift given by the French to their fellow republicans

Location: Liberty Island, NYC Height: 151 feet, 1 inch Weight: 204.1 metric tons

reflection on its gold plating.

Torch In 1986, the old torch was replaced. It is now displayed in the lobby. The current torch is illuminated by large spotlights that cast a magnificent

Ladders to the right arm

This area has been closed for many years. The ladders are used by the maintenance team when repairs are necessary

Staircases

There are two spiral staircases that wind around a central column. One staircase is ascending while the other is used for the descent.



The observation platform is situated at the top of the statue. There is space here for 30 people. The platform affords a magnificent view through 25 windows in the crown.

Tablet of the Law

The Tablet of the Law is situated in the left hand of the statue which represents the Goddess of liberty. It bears the Roman letters for the date 4 July 1776, American Independence Day.

Girders and staircases

Here we see the original skeletal frame of the Statue of Liberty. Around it we see the staircases that lead to the viewing platform.

Foot of the statue

Six stories above the base, this landing takes the visitor to the fourth level which is situated at the foot of the statue. From here the visitors can access the spiral staircase that leads to the viewing platform 12 stories above.

Pedestal

Once the visitor enters through doors at the base of the pedestal. they find a stairway that leads up to the second level.

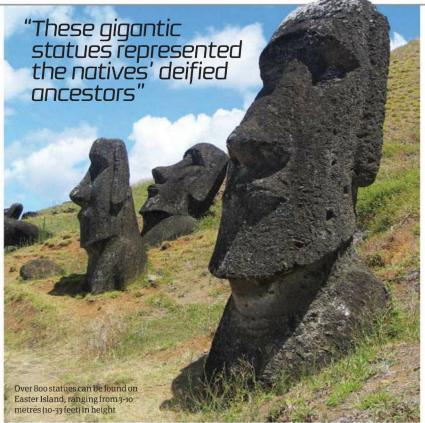
Pavement

The pavement is situated between the walls and the lawns. It allows the visitors to take in a vertical view of the statue and leads them to the door of the monument.





Easter Island's statues



Constructing Easter Island's statues

How did the natives of this Polynesian island build and move its synonymous giant stone monoliths?



The giant stone statues (moai) on Easter Island, a Polynesian island in the south-eastern Pacific Ocean, were built by ancient islanders

between the years 1000 and 1500 AD. Ranging in height from 3-10 metres (10-33 feet) and weighing up to 86 tons, these gigantic statues represented the natives' deified ancestors, positioned to gaze over their lands as a protective and watchful presence. Importantly, while often referred to as the 'Giant Stone Heads of Easter Island', the carvings are actually heads and torsos, with many simply buried up to their head due to landscape change over the centuries.

The statues themselves were constructed out of the volcanic rock from which the island itself was made. The majority were carved from compressed volcanic ash, although some from basalt and trachyte. This rock was quarried from the slopes of the island's volcanic crater Rano Raraku. The tools used to carve them were

stone hand chisels, sharpened by simply breaking off the dulled striking end. After being carved, the moai statues were then transported to areas around the island and placed on ahu, holy pedestals constructed from crushed rock.

Without modern-day technology, however, moving these statues would have been a Herculean task. As no written records of the process exists – with only debatable oral tradition surviving – current academic thought leans towards two possible methods. The first was to strap a wooden sled to the statue and then pull it over onto wooden rollers, while the second was far more elaborate and involved employing a specially constructed A-frame-like structure which, once attached to the statue, would pitch it forward and upward when operated by the islanders.

Check out the 'Two wooden fingers' boxout to the right for a visual step-by-step guide of how the latter process might have worked.

Two wooden fingers

Explaining one theory of how the ancient population of Easter Island could have moved these gigantic statues

Sled heads

Once carved from volcanic rock, the statues are believed to have been strapped in their standing position to giant wooden sleds.

Two fingers

Ropes were then cast around the heads and attached to a 'miro manga erua' (translated as 'two wooden fingers' in native Polynesian), an A-frame-like structure.



Tug of war

The rope was then extended from the head over the top of the frame and pulled out in front of the standing statue. With the feet of the A-frame positioned before the statue, a team of islanders would then pull the rope, dragging the statue forward and, as a consequence of the frame, upwards.

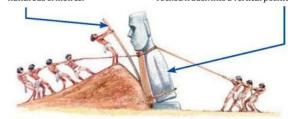


Rock...

By repeatedly initiating this forwards and upwards motion, the islanders could move the statue over hundreds of metres.

...and rest

When the resting position of the statue had been reached, the frame could then be used to hoist it onto a plinth and removed, before a second team rocked it back into a vertical position.



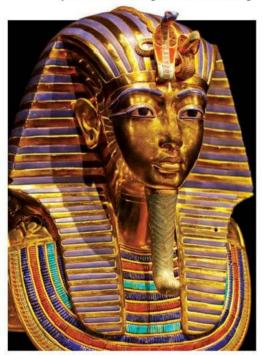


Inside Tutankhamun's

Houses of Eternity were the final resting place of the pharaohs, including the most famous young ruler of Egypt



The world's greatest archaeological discovery was revealed when the tomb of Tutankhamun was opened by Howard Carter in November 1922. Tutankhamun's grave was hewn during

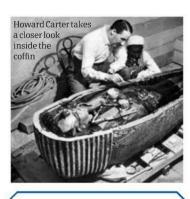


Egypt's 18th dynasty - by this time, the embalmers had perfected the art of mummification, and craftsmen, the art of tomb building. They cut the burial chambers with simple tools like wooden hammers and copper chisels. The interior was decorated with religious and magical inscriptions that were believed to empower the dead.

The body of Tutankhamun was buried in the Valley of the Kings near modern-day Luxor. The Valley was protected by a sacred mountain that seemed to swallow the setting Sun. In antiquity, this strange and atmospheric burial ground was shrouded in mystery; the craftsmen who worked there were separated from society and established in a remote desert town.

Secrecy was essential to the prevention of ancient tomb robbery, for many individuals risked life and limb in order to plunder the resting places of their royal ancestors. The tomb, known as a House of Eternity, contained unimaginable riches. Inevitably, as time passed, most of the royal tombs were looted by ancient treasure hunters. Fortunately, the tomb of Tutankhamun survived detection - probably as it was small and well hidden; over time it was gradually forgotten.

Inside the funeral chambers, a plethora of grave goods had survived. These treasures included great golden shrines and magnificent coffins; on a smaller scale, Carter found caskets of the king's linen clothing - these included tunics that still bore rich bands of embroidery, while among the pharaoh's family heirlooms was a lock of his grandmother's hair. All finds, from the splendid funerary mask to the small floral garlands found on Tutankhamun's mummy, are equally invaluable to our understanding of the life of this enigmatic young ruler.



Child of the Sun

Who was Tutankhamun?

Tutankhamun began his life as Tutankhaten; the name highlights his role as the 'living image of the sun disc'. Tutankhamun was the last ruler of a magnificent dynasty. His father is most likely to have been Akhenaten, Egypt's 'heretic' pharaoh. Akhenaten had shocked the world with his worship of a single solar deity - the Aten. On his accession, Tutankhamun faced a great period of transition as he re-established the old gods. Being young, his rule was dominated by a controversial figure - his uncle, the military commander, Ay.

Tutankhamun died between the ages of 18 and 20 when the throne passed to Ay. Some believe that the young king was assassinated.

Tomb of Gold

The antechamber

Contained a mass of 700 objects. Clearing it was like 'playing a gigantic game of spillikins [pick-up straws], according to Carter.

The annexe

The last room to be sealed in antiquity, the annexe was designed to hold oils, perfumes, food and wine

The entrance

Once covered by workmen's huts, the tomb entrance was reached by a series of 12 steps.

The burial chamber

Contains the burial equipment of Tutankhamun. Here, Carter found the sarcophagus, coffins and human remains.

The treasury

Contains the king's viscera, which were placed in a large golden shrine. It also contained a statue of Anubis, protector of the dead.



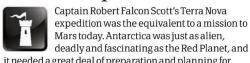
Opened on 25 November 1922, it was filled to the ceiling with rubble. Among the debris, Carter found clay seals, ivory fragments and water skins.



The South Pole

The race to the South Pole

Turning a spotlight on Captain Scott's ill-fated expedition to Antarctica



it needed a great deal of preparation and planning for anyone to even contemplate making it to the South Pole.

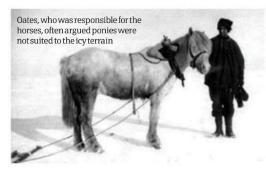
To reach the Antarctic, Scott bought the Terra Nova, an old whaling ship that was reinforced with 2.1-metre (seven-foot) oak beams from bow to stern. Transport on the ice consisted of three motorised sledges and 44 normal sledges. They brought 19 ponies and 33 dogs with them to pull the sledges, though Scott always planned to man-haul these on the final leg of the journey.

To deal with the weather that can range from -30 degrees Celsius (-22 degrees Fahrenheit) in the summer to -60 degrees Celsius (-76 degrees Fahrenheit) in the winter, they wore wool and fur-lined waterproof clothing, mittens and finnesko (reindeer skin) boots. Tinted goggles were also used to help prevent snow blindness.

Away from base camp, paraffin-fuelled Primus stoves were employed to heat the explorers' meals and drinks. Much of their diet comprised a mixture of mincemeat and oil called pemmican; this was combined with melted snow to make a stew called hoosh. Daily rations also included hard, high-protein biscuits, tea and cocoa. They slept in four-man tents that consisted of four bamboo corner poles covered with a lined canvas fabric.

Throughout the journey of the Terra Nova, observations were made of the marine biology, meteorology and currents, tides, salinity and the temperature of the sea. On reaching Antarctica, two geological journeys were carried out to explore the geology of the Western Mountains, and a three-man team made a special study of the emperor penguin.

They collected 2,109 animals and fish, of which 401 had never been documented before, along with samples of volcanic rock and fossilised plants. More meteorological data was collected and they carried out hydrographic measurements of both land and sea.



The main party headed by Scott spent their time laying depots of supplies and food to support the journey to the South Pole, which they eventually reached on 17 January 1912. Pipped to the post by Norwegian explorer Roald Amundsen, Scott's team died from a combination of dehydration, hypothermia and scurvy on their return to base. Their bodies were found on 12 November 1912.

Although ending in tragedy, Scott and his men were hailed as patriotic heroes who fought and lost against great odds. They certainly left a legacy of scientific research that still helps us today to understand the many mysteries of the Antarctic.

organising the stores and planning the logistics for the march to the Pole.



Edward Atkinson, a physician and parasitologist, conducted scientific research in the hut at the Cape Evans base



The Terra Nova, the former whaling ship after which the expedition was named



The statistics...



James Clark Ross

Commanding two vessels, HMS Erebus and HMS Terror, Ross charted the Antarctic coastline from 1839-43. He discovered it is a continent and set a record for sailing so far south.

Roald Amundsen

Amundsen's team was 2 regarded as more skilful on skis, and benefited from using dog sledges. He was also the first undisputed man to reach the North Pole.

Ernest Henry Shackleton

Shackleton was part of Scott's 1901-04 Discovery expedition. He lead his own 1907-1909 Nimrod expedition, which discovered the Beardmore Glacier.

Richard E Byrd

4 Byrd was the first person to fly to the South Pole. Using a Ford Trimotor from his Little America base on 28 November 1929.

Carl Anton Larsen

Larsen led the first Norwegian Antarctic expedition from 1892-94. In 1893, he was the first to use skis on Antarctica where he discovered the Larsen Ice Shelf.

DIDYOU KNOW? Scott's last journal entry on 29 March 1912 talks of his companions' 'hardihood, endurance and courage'

Inside Scott's hut

The prefabricated hut only took two weeks to build after Scott landed at Cape Evans on 4 January 1911. It measured 7.6 metres (25 feet) wide, 15.2 metres (50 feet) long and 2.7 metres (nine feet) high.

The wood board walls were insulated with ruberoid and shredded seaweed inside jute lining bags, and it was heated by a seal blubber-fuelled stove. It featured living quarters, bunk beds and laboratories. Stables were built to the north side and a storeroom was added to the south of the hut.

It included a photographic darkroom and the laboratories were filled with radio and chemical equipment, microscopes for examining biological samples, dissecting tables and a range of thermometers and meteorological recording devices including a Dynes anemometer that $measured\ wind\ velocity.\ The\ scientists\ in\ the\ team\ regularly\ lectured\ on$ their research to the rest of the expedition members.

Life in the hut was relatively comfortable. Acetylene generators provided artificial light, while a pianola (autopiano) and a gramophone player entertained them during their limited leisure time. Cooked food was plentiful and varied, and the heating pipes from the stove kept them warm; all a stark contrast to conditions outside the hut.



Learn more

For an in-depth account of the full expedition, take a look at Scott Of The Antarctic: We Shall Die Like Gentlemen by Sue Blackhall.

The race is on...

Scott was not aware he was 'racing' to the South Pole until he received a telegram from Roald Amundsen on 12 October 1910, which read: 'Beg to inform you Fram proceeding Antarctic-Amundsen'. This made Scott even more determined to claim the South Pole for Britain.

16 January 1912 **FLAG**

Scott's five-man team see Amundsen's flag in the distance and realise he has beaten them. They arrive at the South Pole the next day.

The statistics...

Edgar Evans

Lived: 7 March 1876 17 February 1912

Info: Petty officer Evans was a Welshman with a reputation for drinking and womanising, Scott nonetheless admired him for his strength and resourcefulness. He was responsible for loading the sledges and looking after the equipment. Returning from the Pole his mental and physical condition rapidly deteriorated.

The statistics...

Edward Wilson

Lived: 23 July 1872 29 March 1912

Info: The ever-helpful Wilson was the chief of scientific staff. He was a physician and zoologist who had made a special study of penguins, whales and seals in the Antarctic. He was also an accomplished watercolour artist.

17 February 1912 RETURN

At the bottom of the Beardmore Glacier, Edgar Evans dies after suffering severe frostbite. Scott's team encounters

extreme weather.

16 March 1912 SACRIFICE

expedition tent to a certain words, "I am just going outside and may be some time

14 January 1911 **FRAMHEIM**

The Fram, the ship carrying Amundsen, lands at Framheim, in the Bay of Whales where their base is established.

29 March 1912 THE END

In the midst of a blizzard, suffering temperatures of -40 degrees Celsius (-40 degrees Fahrenheit) with no supplies Scott and Wilson die in their tent only 18 kilometres (11 miles) from One Ton Depo

14 December 1911 FIRST ARRIVAL

Roald Amundsen arrives at the South Pole with Olay Biaaland. Helmer Hanssen, Sverre Hassel and Oscar Wisting. They stay on the plateau for three days and name it after King Haakon VII.

3 January 1912 POLAR PLATEAU

Scott traverses the Polar Plateau, and selects the team members who will travel the remaining 269 kilometres (167 miles) to the Pole.

4 December 1911 BEARDMORE GLACIER

Scott's expedition is hit by a blizzard. The ponies are shot and the dogs sent back to base.

24 October 1911 SCOTT'S POLAR JOURNEY

16 men using motor, dog and pony sledges start the journey to the Pole.

4 January 1911 ARRIVAL

Terra Nova lands at the 'Skuary', McMurdo Sound, Ross Island, which they rename Cape Evans.





Stonehenge



How was Stonehenge built? Ahenge is an area containing a circle of either stone or wooden posts, dating from the Neolithic (New Stone Age) and Bronze Ages Stonehenge built?

This monument was constructed by prehistoric men and their bare hands before the invention of the wheel



An enigma of prehistoric civil engineering and a dramatic silhouette on the landscape of Salisbury Plain, the megalithic monuments at Stonehenge are a constant reminder of the

incredible resourcefulness of ancient civilisations.

Construction of Stonehenge was divided into three main stages. The first, between around 3000 and 2500 BC, involved the creation of an ordinary henge monument (a circular enclosure bounded by banks and a ditch) that was initially used for ceremonies and burials.

The second stage saw the arrival of Welsh bluestones from the Preseli mountains. In around 2150 BC, men began transporting these four-ton stones to Wiltshire using a combination of rollers and sledges on land, and

rafts across the sea and rivers. At the end of the 240-mile journey the stones were arranged as a double circle in the centre of the Stonehenge site. These bluestones provided a sacred focus, which Stonehenge experts professors Timothy Darvill and Geoff Wainwright suggest was due to the stones' perceived magic healing powers. Once the stones were set up, the site attracted more interest with visitors and pilgrims from all over northern Europe.

In around 2000 BC, the third phase of construction began when Sarsen stones were transported from a site 25 miles from the monument. These immense stones – the heaviest of which weighed 50 tons – were positioned upright in an outer circle with horizontal lintels running between each vertical.

The history of Stonehenge...

3100 BC

Henge established
The original henge
comprised a ditch, an
earthen bank and the
mysterious Aubrey Holes – a
circle of 96 small pits.

2150 BC

Welsh bluestones arrive
82 stones are transported

82 stones are transported from the Preseli mountains and arranged as a double circle within the henge.

2000 BC

Sarsen stones arrive Each Sarsen is brought to the site from north of Salisbury Plain by 600 men – 500 to pull the sledges with leather ropes and 100 to lay the rollers.

1500 BC

Bluestones moved

The bluestones are rearranged in the semicircle shape we see today. Some of the original stones were broken up or removed.



Timothy Darvill

Professor of Archaeology in the School of Conservation Sciences at Bournemouth University

We speak to Timothy Darvill about the history and significance of this magnificent monument

For what reasons might the makers of Stonehenge have decided to move the bluestones all the way from Wales?

[Professor Geoff Wainwright and I] believe the bluestones, which come from a variety of outcrops on and around the Preseli Hill of North Pembrokeshire, were perceived to have magic powers because of the healing properties associated with holy wells and springs at their source. It is likely that the Preseli Hill lay at the extreme western end of the territory of those who built Stonehenge and so the hills may also have been regarded as a sacred mountain or the home of the gods – a sort of neolithic Mount Olympus.

Have you ever considered how long the site might realistically be preserved against the effects of the elements, acid rain and so

on? We've seen photos of birds nesting in holes caused by such erosion...

Thanks to the efforts of English Heritage, the site is well looked after and in no great danger. There is very little erosion going on and the only concern is some natural or human catastrophe, the stones are already 5,000 years old and still looking good (although there was some cosmetic surgery in the Fifties and early-Sixties when some were straightened and others re-erected).

How do archaeologists go about chronicling the timing of the different phases of Stonehenge's construction?

Two ways. First is what is known as stratigraphic: the order or sequence of events and structures revealed through excavations and surveys. Second is chronological: adding dates to events within the stratigraphic sequence through the use of radiocarbon dating. Our excavation in 2008 was the first for more than 40 years and we are still working on the samples we took.

Why has Stonehenge become the go-to henge for people around the world?

Stonehenge is a must-see site because it is so unusual and so enigmatic. People love the debate of interpretation.

Professor Timothy Darvill is the author of *Stonehenge: The Biography Of A Landscape* available from www. thehistorypress.co.uk.



Shropshire's Iron Bridge

Coalbrookdale's Iron Bridge was a prime example of the transforming power of British engineering



The town of Coalbrookdale might seem an unlikely choice for a construction that came to define Britain's industrial potential, but in the 18th Century it was a very different place.

Shropshire was one of the UK's leading producers of coal with a nearby blast furnace recently built, but only six ferry crossings in the immediate area. As a result, in 1779 a team of entrepreneurs led by architect Thomas Farnolls Pritchard, proposed initial designs for what came to be the world's first cast iron bridge.

Needing to span 120ft of the River Severn with a single arch, it cost around $\it E6$,000 (over $\it E1.5$ million in today's money). It also went through several designs before Pritchard died a month into its construction. Although the history of its construction has largely been lost, we do know the impact Iron Bridge had on the town and its surroundings, with a tourist and business population growing after its opening. It also became the design model for cast iron bridges that followed.



Big Ben

The untold saga of Britain's most famous bell



Though synonymous with the clock tower, 'Big Ben' is the nickname of the 13-ton bell at the heart of the building. Big Ben was cast by Warners of Norton

near Stockton-on-Tees in August 1856 and taken to London by rail and sea, and crossed Westminster Bridge on a carriage pulled by 16 white horses.

Before being winched up the tower, it was tested daily until in October 1857 a huge crack appeared. Warners blamed the clockmaker for upping the hammer's weight from 355kg to 660kg and demanded a fortune to start over. So it was decided the new bell would be cast by George Mears at the Whitechapel Bell Foundry. Mears' bell was 2.5 tons lighter but had to ascend the tower on its side – a task that took 30 hours. Then, in September 1859 the new bell also cracked and didn't ring for four years until Sir George Airy, the Astronomer Royal, suggested turning the bell and cutting a square into the metal to halt the crack, plus using a lighter hammer. And this is the bell we hear today.





Hadrian's Wall

Was this ancient man-made border really built to exclude the Scots?



An enduring sight on the rural landscape of northern England, Hadrian's Wall stands as a symbol of Roman engineering. Commissioned by Emperor Hadrian in 122AD, for around six

years three legions of the Roman army worked on its construction. At 73 miles the fortification is northern Europe's largest ancient monument, extending across the north of England from Bowness-on-Solway in the west to Wallsend near Newcastle-upon-Tyne in the east.

45 miles of the eastern portion was constructed from local stone with an inner core of rubble. The area to the west, meanwhile, consisted of a turf barrier made with a cobbled base. Hadrian's Wall was mistakenly thought to have been built to keep the Scots out, but historians believe it was likely built as a form of border control to monitor population flow between England and Scotland.



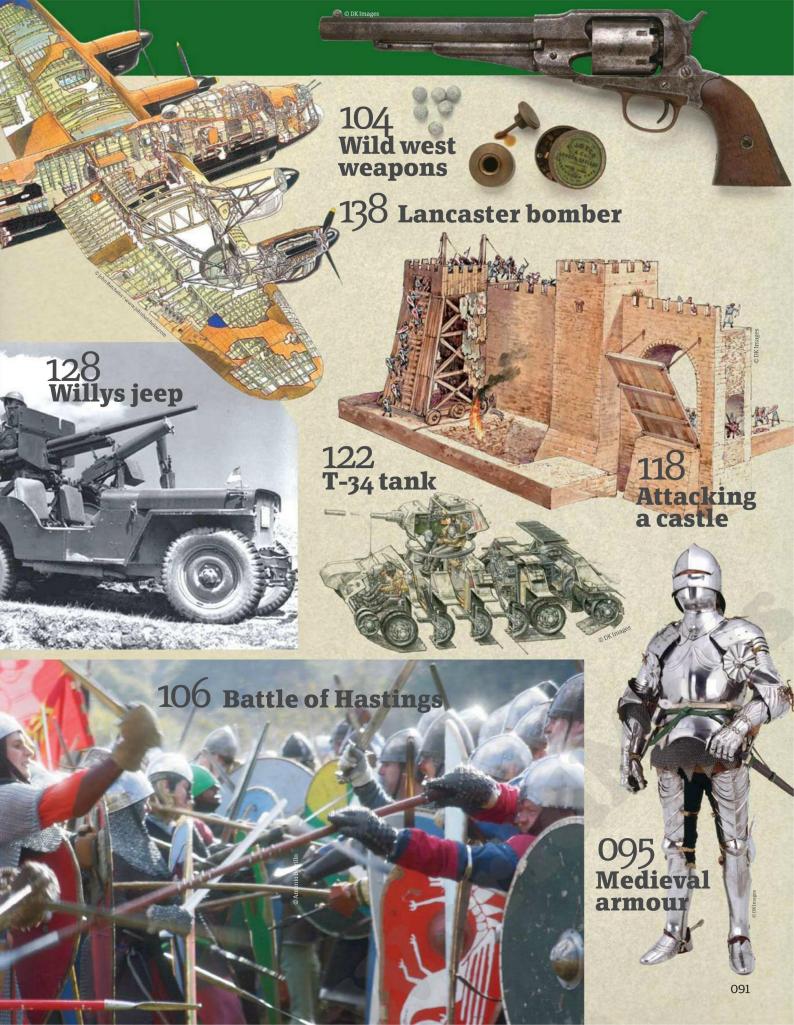


- O92 Roman forts
 Take a look inside these
 Roman strongholds
- O94 Life as a Roman soldier
 Find out why these soldiers were the heart and soul of the Empire
- **Medieval armour**Discover the parts that made up a suit of armour
- O96 **Samurai armour**The clothing that was more than just protection
- O97 **Viking warriors**How did these warriors wreak havoc?
- **Greek warships**See what made triremes the ultimate fighting machine
- **Man of war**The most prominent ships from the 16th to 19th Century
- **HMS Victory**Dissecting one of the most famous ships ever
- 104 Wild west weaponry
 The pistols and rifles that
 won the west
- 106 Battle of Hastings
 The story behind one of
 Britain's most important and
 brutal conflicts
- The Gunpowder Plot
 Why will we always remember
 the 5th of November?
- 112 Siege towers
 Find out how to get troops
 over a castle wall
- **The crossbow**A powerful weapon that had a huge impact in battle

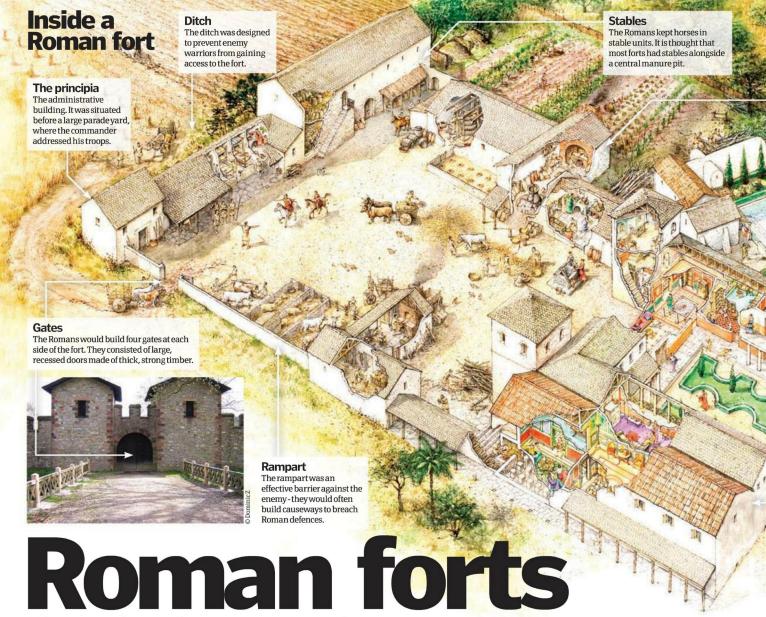
- **Sword fights**The techniques used to defeat your foe
- **Naval mines**What made these deadly sea bombs detonate?
- **Duelling**The chivalry behind a duel
- **Trebuchets**The physics behind these impressive machines
- **Gun turrets**Inside these deadly structures
- The cannon

 Powerful tools that changed the face of warfare
- 117 Hill forts
 A tactical way to defend against attacks
- 118 Attacking a castle
 Techniques of both attack
 and defence
- 120 Mark I tank
 The vehicle that heralded a
 new era of armed conflict
- **T-34 tank**A Soviet tank that had a big influence on Word War Two
- 124 The Tiger tank
 The German tank of
 choice that had some
 serious firepower
- **Churchill tank**A defensive powerhouse the aided British success
- **Willys jeep**Taking a look at this versatile light transport vehicle
- **V-1 flying bomb**The bomb that could destroy all in its path

- **Bouncing bombs**The way to bring down a dam
- 131 Battering rams
 Breaking down walls
- 132 Battle of Britain
 An aerial battle like no other
- **Supermarine Spitfire** Inside the iconic fighter
- 138 Lancaster bomber
 The real Dam Buster
- **Messerschmitt**Building this German plane
- **B-17 Flying Fortress**A key weapon of WWII
- **Avro Vulcan**The first delta-winged bomber
- **Dassault Mirage**Welcoming a new type of jet
- **Chariots**An ancient vehicle of war
- **Samurai swords**Not your average sword
- **The longbow**The archer's ideal weapon
- **Flails**A crushingly powerful tool
- **Pirate cutlass**The navy's favourite sword







Discover how the Roman invaders constructed their many strongholds around Britain



When the Romans invaded Britain, they monopolised native strongholds. As time passed, they built base camps that allowed their armies to travel safely

through the country. At first they fortified these camps with timber, then from the 2nd Century AD they used stone. The Romans were expert builders and had perfected the art of masonry by creating a revolutionary new material that was known as 'opus caementicium' – a concrete made of rock, rubble or ceramic tiles. Walls were built by placing mortar and stone in large wooden frames, and the result was a facing that has endured centuries. Opus caementicium was regarded as an innovative

discovery, enabling the Romans to create complex structures such as the arch and the dome.

Engineers built their forts on modified terrain – often choosing the summit or the side of a low hill, near a river or stream. Roman strongholds were built by a specialist corp that included a chief engineer; much of the manual work was undertaken by soldiers. Officers known as metatores were sent to mark out the ground for an encampment, using a graduated measuring rod known as a decempeda. Each fort was erected with a wide ditch, and also included a stockade or defensive barrier made of timber posts or stone. The Romans used the residue earth from the ditch to create a rampart. While

tradition dictated that each fort had four stone gateways, it was equipped with watchtowers that could reach an impressive nine metres (30 feet) high.

The fort worked on many levels – it served as a barracks, hospital, workshop, granary and stables. Every structure included a main street that ran unimpeded through the camp. In the centre was a parade yard and a commander's headquarters.

The Romans placed great emphasis on cleanliness, and so sanitary conditions were especially important. Forts had public baths and private latrines, consisting of rows of seats situated over a channel of running water. Drinking water, meanwhile, came from wells.

5 TOP FACTS ROMAN FORTS

Gods of War

We can learn a great deal about the Roman religion by looking at portable altars that were found at forts. British finds include images of Minerva, the goddess of righteous warfare.

The hospital

2 This was a rectangular building that could house up to 60 wards. Hospitals are thought to have contained small hearths, used for the sterilisation of instruments.

Cleanliness

Large forts had bath houses in the central area of the camp. Places of relaxation and gambling, they often contained an altar dedicated to the goddess Fortuna.

The games continue

The Romans erected amphitheatres near their forts; the most famous British one was found at Caerleon. Combat between humans and animals was viewed here.

On parade

Soldiers adhered to several official festival days. The most important festival was at the beginning of the year, when they renewed their oath to the Emperor.

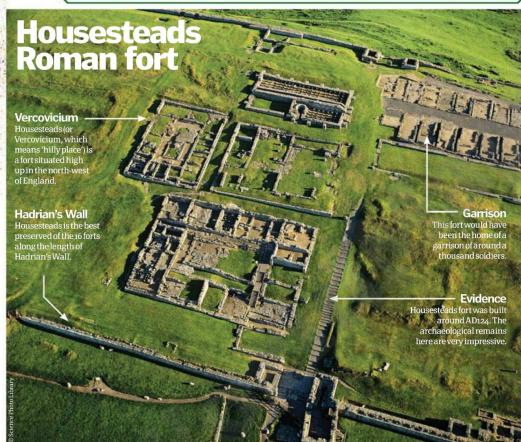
DIDYOUKNOW? The Romans even had a fire brigade. Cooking fires and beacons meant the fort was at risk of being set ablaze



A soldier's life

The buccina (a type of trumpet) marked the start of every new day. The soldiers were highly disciplined – military aspirations and a strict code of honour dominated their lives. They practised sword fighting, hand-to-hand combat and military manoeuvres. Roman soldiers endured a gruelling regime that included running, swimming and marching over long distances. The day of a soldier could be divided into phases that revolved around 'the watch'. There were a series of eight, three-hour watches, known as the 'vigilia', and each change of watch was signalled by the buccinator (buccina player). Sometimes soldiers were ill or sustained injuries, so the Romans instituted a permanent medical corps and hospital in the fort. The fort could also act as a trading station where vendors sold crafts, animals and food. It was here that liaisons, both romantic and political, were established.







Life as a Roman soldier

Despite the long hours, low pay and high mortality rate, soldiers were always the backbone of the Roman Empire



For nearly 500 years, one of the most sought after jobs in the world was that of a Roman soldier. Not because

of the conditions - which were brutal or the pay-which was infrequent-but because soldiers were Roman citizens. entitled to retire with a state pension or land and a rare chance for foreigners to become part of the greatest empire

Soldiers had to be at least 20 years old, serve for at least 25 years and were not allowed to marry. Although their training and formations changed, they were trained as infantry (either light known as Velites or heavy known as Hoplites) or cavalry and organised into legions of up to 5,000 infantry and 250 cavalry each.

When not on military exercises, soldiers spent their days training and patrolling, marching up to 20 miles a day in full armour before having to make or secure camp - digging and staking out the perimeter and protecting it with walls of wooden stakes, that also had to be carried when the unit decamped. Their diet consisted of unleavened bread, vegetables or porridge with wine where the location permitted, although this and fresh meat were usually reserved for centurions and generals.

However, it was in battle that the soldier earned his reputation, thanks to the years of training and discipline that inspired fear in all but the later Barbarian hordes that faced them. Armed with shields, swords, daggers spears or javelins, soldiers typically $fought\,in\,lines, forming\,a\,wall\,of\,shields$ against the enemy. They had to do precisely as they were told or face flogging, losing limbs and, for the crime of desertion, beheading.



Shields were usually made from wood and could be circular, oval or rectangular.

Breastplate

Breastplates and armour were made from metal strips held together with metal iron or leather ties. They were so heavy. soldiers had to help each other into them.

Tunic

Woollen tunics were worn to prevent chafing from the heavy metallic armour. They covered most of the torso.

A Roman soldier's kit

When not in battle, Roman soldiers carried basic provisions with them. This included a dish, a cooking pan, and up to three days' rations. Sometimes, they carried extra clothing and an axe to help set up camp...

Sword

Soldiers usually carried a gladius-a short iron weapon designed for rapid stabbing movements.

Helmet

The helmet was made from iron, brass or bronze and lined with leather to prevent bruising the skin.



First among equals

According to the historian Livy, Rome was originally defended by 1,000 men raised from the city's three founding tribes.

The Tortoise

Soldiers could adopt their trademark Tortoise formation by locking the edges of their shiel together. It allowed them to advance while under fire from arrows, rocks and burning oil.

3 Punishment In the early Empire, if an entire unit deserted in battle, one in ten of them would be put to death. Soldiers could also be beh tortured, fined or deprived of citizenship.

Gladiators

Captured enemy soldiers of suitable age and physique were trained to be Gladiators effectively an extended death sentence played out for public

Weaponry

Romans (and Greeks before them) used 'bullets' - usually made from lead, stone or clay and fired by a sling, not a gun.

Shoes

Sandals and leg-guards were made from leather. Required to survive battle as well as daily marching, sandals were often reinforced with metal studs to make them last longer.

Head to Head **ARMOURS**

ceremonial roles and historical re-enactments.



1. German called 'Gothic' and had brutal lines and pointed tips. Germany was a centr of armour production in



the 'Milanese' style, Italian armour was highly decorative and among



3. Spanish armour created in the medieval period came from Spain. Some were made from Toledo steel, seen to

DIDYOUKNOW? Until the early 15th Century, knights would wear cloth surcoats over their chain mail and plate armour



Samurai armour

The samurai, Japan's warrior elite for centuries, sported armour that offered both protection in warfare and ornamentation for ceremonial purposes



Tied to their elite position in society as the ruling class of feudal Japan, a

samurai's armour first offered them a large amount of protection while on the battlefield. Alongside this they also displayed their highly influential culture and traditions, appearing both ornamental and radically stylised.

The armour was a combination of iron, silk, leather and bronze, and consisted of a helmet, cuirass, shoulder guards, shin guards, face mask and skirt. The armour was created by tying small iron plates together with cord, lacquering the resultant strips to protect against rust, and then joining them together horizontally with silken cords to produce the larger armoured panels. Over this a large surcoat was then adopted, made from silk and heavily embroidered.

The samurai's helmet was made from iron and bronze and consisted of a forged bowl to which layered armoured plates were riveted to protect the neck. Upon the helmet was then affixed a maedate, a crest that would slot above the helmet's peak. The crest was often horned, referred to as the kuwagata, and was designed to expound the

samurai's clan, religion or even political bias.

While samurai armour evolved over their centuries in power, the golden age of armour creation is considered by military historians to be between the 12th and 14th Centuries, and is referred to as the o-yoroi style. This style was highly ornate with much silk and embroidery – due to their position at the top-end of society's ladder – but also square and box-like, due to the early engineering being utilised by Japanese armourers.





Samurai weapons Largely abandoning the bow, samurai relied on numerous hand-to-hand weapons to conquer their foe

Tach

The tachi was the primary sword carried by the samurai. It was later replaced by the katana. The tachi and katana were seen to be an intrinsic part of the samurai, which were one with each other.

Wakizashi

The wakizashi was a smaller, secondary blade carried by samurai that resembled an elongated dagger. The wakizashi was never supposed to leave the samurai's side and was the weapon used for ritual suicide if defeated in battle.

Yari

During war samurai also carried spears, referred to as yari, that they used to dismount opponents on horseback.
Towards the latter part of the samurai's dominance in Japan, they were used as warfare became more structured.



Responsible for mass pillaging and sacking over western Europe throughout the 9th to 11th Centuries AD, Vikings were fearsome warriors

Viking Warriors

From the earliest reported raids in the 790s
AD, the Vikings – Scandinavian explorers,
warriors, merchants and pirates – wreaked
havoc among western Europe, sacking

towns, besieging cities and conquering nations. Indeed, it wasn't until the Norman conquest of 1066 that the Viking age was finally extinguished, a period of time that left a marked, lasting imprint on the continent – one that is still evident today.

Foremost of these echoes are the burial mounds of their warrior kings, tombs laden with the treasures, armour and weaponry that they won and possessed during their conquests. Gigantic axes capable of splitting a man's head in two, swords with jewelled hilts and blades longer than a metre and intimidating masked helmets have been unearthed, telling a story – albeit incomplete – of the lives and battles these humans lived. A great example of this custom can be seen in the burial complex at Sutton Hoo, Suffolk, England, an outstanding undisturbed ship burial that relinquished a wealth of Anglo-Saxon artefacts.

Other traces of this warrior culture have transcended the ages via runestones, these markers were left by Vikings to commemorate great victories, exhibitions or disasters that befell them on their travels. One of the most notable examples, and one that best helps us to understand the travelling-band nature of Viking forces, is the Ingvar runestones located in modern-day Sweden. This series of 26 stones was erected as a monument to fallen members of Ingvar the Far-Travelled's 1036-1041 expedition to the Caspian Sea. The stones tell of a great battle (probably the battle of Sasireti, Georgia) where many men died. One of the most poignant reads: "Þorfríðr raised this stone in memory of Gauti, his son. Gauti met his end in Ingvarr's troop".

This was the fundamental polarisation of the Viking way of life. Their exploratory nature and fierce combative skills won them much during early-medieval Europe, with great cities and cultures ravaged by their roving bands. However, as they eventually learned in 1066, if you live by the sword, you die by it also.



The oarsmen

Rowers consisted not of slaves but of free men and hired foreigners. The oarsmen were divided into three groups. The thranitai occupied the top section of the ship – a position that was relatively comfortable in comparison with conditions below. However, added strength and agility was required of these men. The middle section, who were known as the zygitai, rowed directly beneath the thranitai although at a slightly different angle, while the lowest set of rowers, the thalamitai, were seated in dismal surroundings at the bottom of the ship. The heat here was intense. The oarsmen were particularly vulnerable during enemy engagement and if the rowers were captured, the enemy would dismember their thumbs or cut off their hands. Moreover, if they were trapped below deck during a hostile encounter they risked drowning.

The akrostolio

To complement the bow, the stern was designed with a tail so that the ship resembled a mythological sea monster.

Helmsman position

The helmsman was placed at the stern so that he was able to guide and command the ship.

Captain's seat

The seat was designed at the rear of the ship for the benefit of the commanding officer.

Archers and spearmen

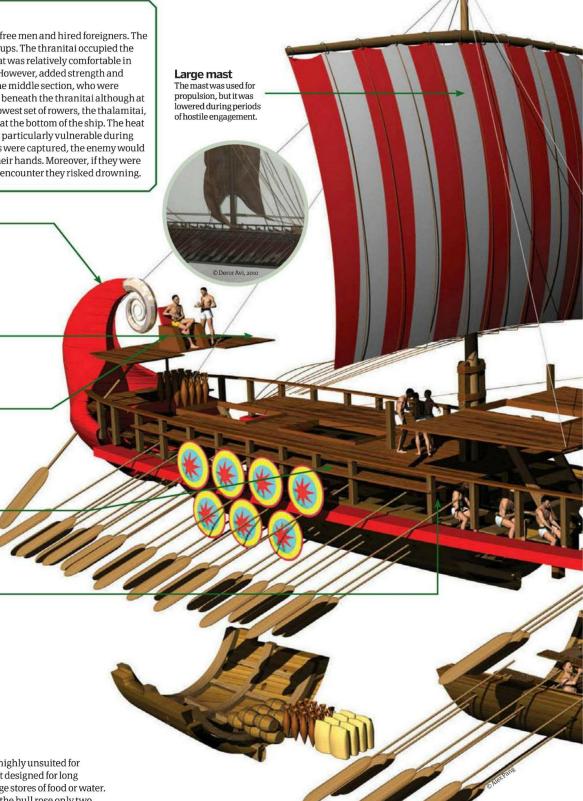
Marines were placed along each side of the vessel to protect the ship during battle.

The oarsmen

Rowers were placed at three levels on the ship. At the top, 62 thranitai, in the middle 54 zygitai and the lowest level 54 thalamitai.

Inside a trireme

The trireme was a long, narrow vessel highly unsuited for habitation. As a military ship, it was not designed for long journeys and there was no room for large stores of food or water. The ship was designed so the height of the hull rose only two metres above the water level, its draught was shallow and its keel was flat, allowing the crew to carry the ship to shore each night.



DIDYOUKNOW? In 1987 scholars in Greece built a replica trireme called Olympias

Greek warships

Triremes – the ultimate fighting machines



First used in the 8th Century BC, the trireme was a state-ofthe-art military machine. Fast and

agile, triremes were designed to exert maximum power during military engagements. Both the Greeks and the Phoenicians employed these ships for military and trading purposes – its name is derived from its ability to seat three levels of rowers who were positioned on both sides of the vessel. Triremes played

an essential role in the Persian wars becoming an important symbol of Athenian military capability. By the 5th Century BC these ships came to dominate the waters around the eastern Mediterranean.

Construction of the triremes began with the hull. Later, the builders added wooden ribs in order to strengthen the vessel, these were reinforced with ropes that were fitted to the keel and stretched tightly over the timber. The ships were built with soft woods – namely pine and fir –

while larch was employed for the interior of the vessel, the keel was made of oak.

The crew consisted of 200 men, this included rowers, a marine corp (comprising archers and spearmen) and a deck crew who were under the command of the helmsman. Due to its design the trireme was meant to undertake short, swift operations. At night, the ships would pull into harbour where the crew would collect fresh water and store it for the next stage of the journey.

The bow

The bow was

decorated with an eye

that was designed to repel evil spirits.

Primary propulsion came from the oarsmen, this included one man per oar. While the ship was designed with two masts, its steering was actually controlled by two large paddles that were positioned at the stern. It is believed that the trireme could sail at six to eight knots; the distance it travelled depended entirely on the weather and its overall manpower. In favourable conditions, it was thought that the oarsmen were able to propel the ship 50 or 60 miles over a sevenhour period.

Ropes

Ropes were made of hemp or papyrus and were protected from humid conditions by being painted with several layers of tar.

Lookout

The prõreus was placed at the foredeck as a lookout.

Battle tactics

Athenian military operations depended on their close-quarters battle tactics, namely the ramming and boarding of enemy ships. The ram of the trireme was built at the front of the ship creating a large metal horn. When the ship attacked it would come in from the stern and attempt to rupture the hull of the enemy ship. A small number of marines were placed on the deck of the ship. They would defend or attack, attempting to board the enemy vessel armed with shields, spears and archery equipment. A squadron of triremes employed a wide range of battle tactics, these included a manoeuvre that was designed to outflank and encircle the enemy before attacking the rear of their ship.

A ram on show at the Israeli National Maritime Museum

The ram

The ram was made of copper or bronze and was designed to rupture enemy vessels.

Why did the ancients give their ships female names?

There are many theories and no clear answers. Triremes, with only rare exceptions, were named after female deities or mythological figures. The Greeks named their ships after sea nymphs like Thetis or Charis or after women of legendary courage, such as Danae or Prokne. In ancient times the ship would also sail under a female figurehead that would guide or protect the vessel – before leaving port prayers and sacrifices were made to a goddess who was thought to safeguard the journey. The all-male crew may have associated their ship with the female shape and form – the boat, being a vessel of men, had clear female principles.

O

Learn more

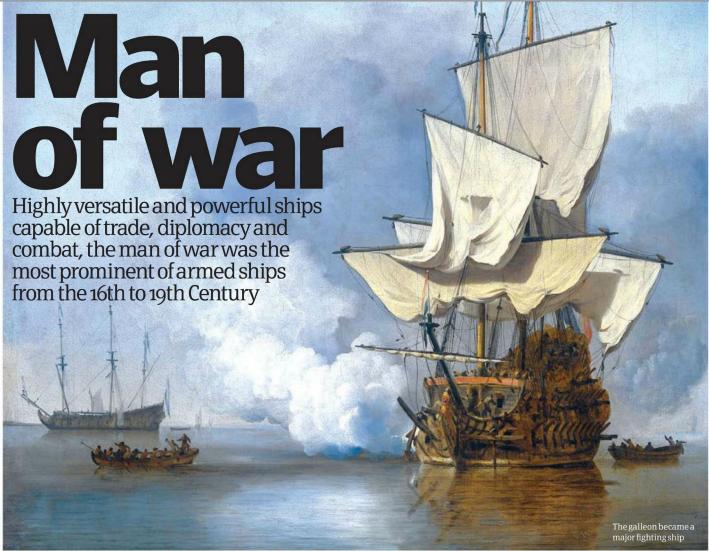
For more information about these incredible ancient warships why not visit the Hellenic Navy webpage, which can be found at www.hellenicnavy.gr.

large amounts of food or water, and therefore long journeys were kept to a minimum.

There wasn't much room to store

Storage







Spanning a variety of ship designs from the 1500s to 1850, but typified by the galleon and ship of the line class of vessels, man of war ships were

exemplars of ship-building expertise, delivering high manoeuvrability, storage capacity and firepower. They worked by taking the roundship and cog ship designs that had been the staple for European trade, transport and warfare since medieval times – both were powered by oars instead of sails – and added multiple masts, decks and cannons as well as more advanced rudder systems. These additions meant that long-scale voyages were now possible, opening up the largely uncharted world to nations and merchants looking to exploit the Earth's natural resources – events that lead to the great Age of Discovery.

One of the most notable man of war ship designs was that devised by Sir John Hawkins, treasurer and controller of the British Royal Navy for Elizabeth the 1st, and a key player in defeating the Spanish Armada in 1588. Hawkins' man of war – a name chosen by Henry VIII – was adapted from the

Spanish galleon and Portuguese carrack and had three masts, was 60 metres long and sported a maximum of 124 cannons, four at the front, eight at the back and 56 on each side. Powered by sail and with a high (for the time) top speed of nine knots, Hawkins' man of war proved to be incredibly successful through the 17th and 18th Centuries. It was chosen and adapted by Sir Francis Drake on numerous expeditions.

The last man of war ships to be designed were the grade-1 listed ships of the line in the late 18th and 19th Centuries. These were colossal warships designed to be used in line of battle warfare, a naval tactic where two columns of opposing ships would try to out-manoeuvre each other to bring their largest cannons into range of the enemy. They were built primarily for combat and, as demonstrated on Lord Nelson's flagship HMS Victory – which sported a massive array of 32, 24 and 12-pounder cannons – were incredibly well-armed. For these first-rate ships of the line, trade was merely an afterthought, coming behind transport, diplomacy and combat in both functionally and priority.



Caravel

The man of war developed from the earlier Portuguese trading ship the caravel, which as designed by Prince Henry the Navigator for exploration and to expand trade routes.

Galleon

During the 15th Century the caravel was adapted by the Spanish into the larger galleon-type ship. These ships were more heavily armed than their predecessors.

Henry VIII

The first English man of war vas named by Henry VIII in the 16th Century, who used the ships to travel while performing diplomatic missions abroad.

Heading up Henry VIII's naval development was John Hawkins, the ship builder and slave trader who went on to be knighted after the Spanish navy was destroyed in 1588.

The versatility of the man of war didn't go unnoticed, with explorer Sir Francis Drake adapting its design to develop a smaller more agile ship referred to as the frigate.

DID YOU KNOW? The man of war replaced the European cog as the main trading vessel in the 16th and 17th Centuries

Inside the man of war

What made this ship design so dominant for so long?

Masts

Common to man of war ships was a two-to four-mast design. These included the rear mizzen mast, central main mast and forward foremast. Not all man of war ships were square rigged, however.

Quarterdeck

The quarterdeck was the area of the ship where ceremonial functions took place and, while

Man of war evolution

Follow the chronological development of the man of war

15th-16th Century (caravel)

Asmall, highly manoeuvrable sailing ship developed in the 15th Century by the Portuguese, the caravel was the predominant exploration and trading vessel at the



time operating in Europe and Africa. It was also used in naval warfare.

15th-16th Century (carrack)

A three or four-masted ship used in Europe, the carrack is considered the forerunner of the great ships of the age of sail. Slightly larger than the caravel it could undertake longer trading journeys. It was armed with few cannons.

16th-18th Century (galleon)

Used for both trade and warfare, the galleon evolved from the carrack, and included a lowered forecastle and elongated hull for



improved stability and manoeuvrability. It had multiple cannons on multiple decks and became a major fighting ship.

17th-19th Century (frigate)



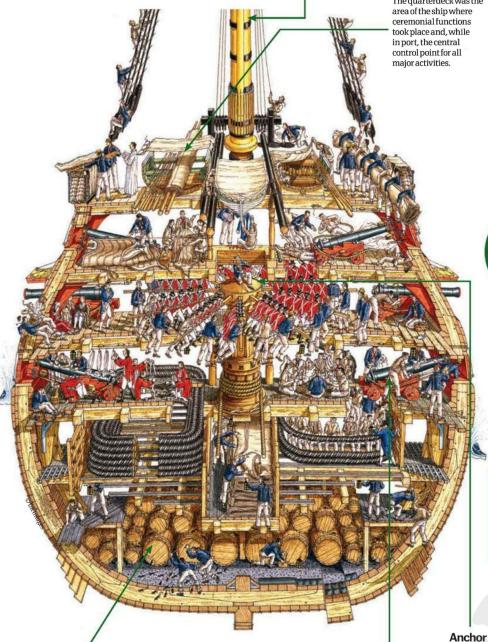
Smaller than galleons, frigates were similar to ships of the line but were faster and lightly armed. They were often used for patrolling and escort

missions as well as protecting trade ships and trade routes with their cannons and crew.

17th-19th Century (ship of the line)

The largest ships built in the great age of sail were ships of the line, massive warships designed to engage with each other in line warfare. These were primarily combat vehicles and sported monumental firepower.





Early man of war ships were primarily used for exploration and trading even though they were armed. Their cargo was diverse due to the exotic locations they visited and included foodstuffs, precious metals and slaves.

Cannons

While various types of cannons were used on man of war ships, 2,540kg demi-cannons were popular thanks to their 490-metre range and six-inch calibre. Demi-culverins and sakers were also installed in various quantities.

Due to the large size of the ships used-with much room needed for their extensive cargo, cannons and crew members-the size of the

anchor was also massive. requiring many men to winch it up from the ocean floor.

HIVIS Victory

One of the most famous ships of all time, HMS Victory was instrumental in ensuring British naval supremacy during the late 18th and early 19th centuries



The only surviving warship to have fought in the American War of Independence, the

French Revolutionary War and the Napoleonic wars, the HMS Victory is one of the most famous ships ever to be built.

An imposing first rate ship of the line - line warfare is characterised by two lines of opposing vessels attempting to outmanoeuvre each other in order to bring their broadside cannons into best range and angle - the Victory was an oceanic behemoth, fitted with three massive gundecks, 104

multiple-ton cannons, a cavernous magazine and a crew of over 800. It was a vessel capable of blowing even the largest enemy vessels out of the water with magnificent ferocity and range, while also outrunning and outmanoeuvring other aggressors.

Historically, it was also to be Vice-Admiral Horatio Lord Nelson's flagship during the epic naval battle off the Cape of Trafalgar, where it partook in the last great line-based conflict of the age, one in which it helped to grant Nelson a decisive victory over the French and Spanish but at the cost of his

Turner's famous painting of the Battle of Trafalgar in which the HMS Victory is shown in the midst of battle

The HMS Victory is a fully rigged ship, with three sets of square sails covering 5,440m2. The breadth of the Victory's sails allowed it to sport a maximum top speed of nine knots when operational, which was for the time very impressive considering its size and weight. During the 18th and 19th centuries a fully rigged ship necessitated three or more masts each of which with square rigging. At full flight the Victory could spread a maximum of 37 sails at one time and could carry 23 spares.

The Statistics HMS Victory



Class: First rate ship of the line Displacement: 3,500 tons Draught: 28ft Propulsion: Sails - 5,440m² Speed: 9 knots (17km/h) Armament: 104 guns

Complement: 800

Crew

There were over 800 people on board the HMS Victory, including gunners, marines, warrant officers and powder monkeys among many others. Life on board was hard for the sailors, who were paid very little for their services and received poor food and little water. Disease was rife too, and punishments for drunkenness, fighting, desertion and mutiny ranged from flogging to hanging.



Back-up

1 Upon completion, the HMS Victory was not put directly into use, but was moored in the River Medway for 13 years until France joined the American War of Independence.

Wood

2 Building the HMS Victory required over 6,000 trees to be cut down, 90 per cent of which were oak. The other ten per cent consisted of elm, pine, fir and lignum vitae.

Mirabilis

3 Victory was commissioned to celebrate the Annus Mirabilis (year of miracles) of 1759, where the British achieved great military success against French-led opponents.

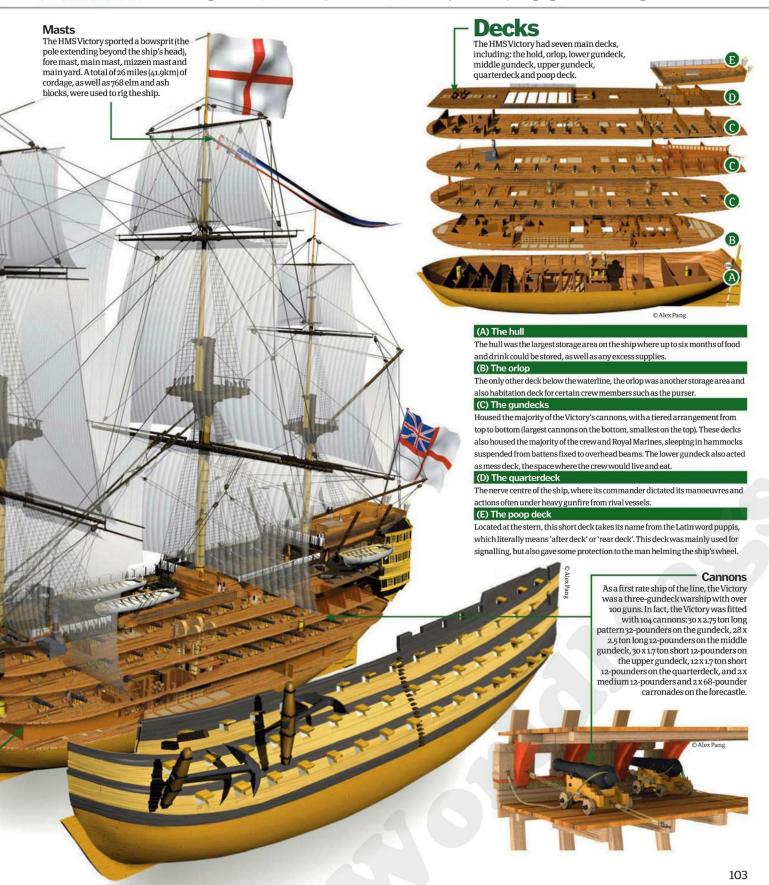
Trafalgar

4 Victory was Nelson's flagship during the famous Battle of Trafalgar in 1805 which, despite Nelson being mortally wounded, saw the British Navy win a decisive victory.

Rest

The HMS Victory was docked down in No 2 Dock Portsmouth - the oldest dry-dock in the world - in 1922 due to deterioration of its bodywork.

DIDYOU KNOW? HMS Victory cost £63,176 when finished in 1765, the equivalent of roughly £7 million today



Brothers in arms

The Clanton and McLaury clan's defiance of Tombstone gun-carrying laws ended in a 15ft space of William Harwood's lumberyard. From the OK Corral, Town Marshall Virgil Earp's call to disarm could be heard; sparking the 19-year old Billy Clanton to draw against Wyatt and miss. The resulting firefight saw Morgan Earp's reply hit Clanton twice in the chest. Wyatt's .44 calibre Smith and Wesson turned on the stomach of Frank McLaury, while unarmed, his younger brother Tom and Ike Clanton tried to run. Ike escaped, but Tom McLaury was hit in the back by a shotgun loaned to Holliday. In just 30 seconds all but Ike from the cowboys were left dying, or dead.

Shooting from the hip

1. Technique:

Draw pistol up, inches from holster; rotate wrist and lower elbow; move gun forward and up towards target; steady with supporting arm and fire!

2. Weapon of choice: Walker Colt's weight did

not lend itself to quick draw, unlike the SAA Peacemaker 1873.

3. A good workman:

Considered by many the fastest, the Sundance Kid (1890s) would be more deadly, accurate, and quicker, because of his tools, than Jesse James (1870s) - but this didn't factor in meanness or even a man's will!

4. The meanest:

John Wesley Hardin; with over 40 kills to his name was reputed to have killed a man simply for snoring!

Vid west

The development of reliable, accurate pistols played a key part in how the west was won



During America's frontier past, westward expansion meant settlers had to protect themselves and the land they had taken from Native

Indian reprisals. Chief concern, the Comanche, could lose nine arrows in the time the Texans took to muzzle-load and fire a musket. The revolving cylinder pistol and lever-action repeating rifles marked the turning point in this battle. Of these, while the black powder .36 calibre 1851 Paterson Colt failed to unseat the mounted Comanche, the Walker Colt, adopted by the Texas Rangers in the 1850s, did not.

The Volcanic repeating rifle fired caseless ammunition known as a 'rocket-ball'. The powder and primer was fused by a binding agent in the hollow rear of the bullet. Unlike the black powder handguns that used paper/cloth cartridges that were susceptible to moisture and so prone to misfire, the rocket-ball was waterproof. Unfortunately, the ammunition - despite its name - was grossly underpowered; it was usurped by the Henry and Winchester rifles of the 1860s.

By the 1870s revolvers benefited from enclosed metal-cased bullet cartridges, which meant all-weather shoot-outs. Their common centerfire rounds were compatible with many Winchester lever-action rifles, allowing the holder to alternate firearms with ease. These modern cartridges and later pistol designs gave rise to Colt's gamechanging Single Action Army 1873. The "Peacemaker" ushered in the typical pistol fighting genre with the line: "God didn't create all men equal, Sam Colt did".

Remington .44

A sturdier and more accurate competitor to the Colt

The Remington Army revolver was a large-framed .44 calibre, with an eight-inch barrel length. It had a six shot cylinder and an eight-inch octagonal barrel. Patented in 1858, it was the major competitor to the Colt .44 in the American Civil War, and many considered it to be more accurate than the Colt. The percussion model could be easily modified to accept cartridges prior to the introduction of the first Remington cartridge revolver in 1875. These percussion revolvers were capable of considerable power with muzzle velocities in the range of 550 to 1,000+ feet per second depending on the charge loaded by the shooter. It has been seen in many movies including Pale Riderand The Good The Bad And The Ugly.



Round bullets

The six chambers could be loaded by dropping in powder charge followed by a round or conical bullet.





Winchester Rifle 'The Gunthat won the West'

The Winchester 1866 succeeded the Henry rifle. Its 'leveraction' mechanism and distinctive side-loading gate allowed the shooter to eject spent cartridges and chamber new rounds from a sealed tubular magazine, all in one movement.

The rifling process, whereby spiral grooves are etched into the gun barrel, helped to impart spin on the passing bullet, enhancing its accuracy in flight.

The 1866 shot .44 rimfire cartridges while the 1873 and later designs chambered 0.44, 0.38 and 0.32 centerfire rounds; used by Colt, Remington and other revolvers. The replaceable primer located in the central base of the cartridge rather than built into the rim meant when struck and ignited the casing could be re-used; an advantage for large rifles where ammunition was expensive.



Side gate

The loading gate on the side and integrated, round sealed magazine covered by a forestock.

Cylinder

Housing a cluster of six to ten barrels which were loaded by a hopper.

Crank

The Gatling Gun required an operator to crank, so it's not a true automatic.

Gatling Gun

Slaughter... with the best of intentions

Gatling's aim was to reduce the need for large armies, and so exposure to battle. However, despite dispensing a murderous 400-1,200 0.45-1 calibre rounds/per min. this gun was initially unpopular. At 90lbs the US Army thought it too unwieldy for combat.

Its cylinder housed a cluster of six to ten barrels turned by a crank shaft; loaded upon rotation by a gravity-fed ammunition hopper. Each barrel had its own breech and

a firing-pin mechanism aligned in a groove in the gun's body. As the barrel rotated the groove pulled the pin backwards, compressing its spring. As a cartridge fell into the breech of the barrel the firing-pin slid from the groove causing the pin to shoot forwards, contacting the cartridge and dispensing its round.

General Custer refused its use in his final fight at the Battle of Little Bighorn. It was only used late in the war against the North.



Head to Head

LAST MAN STANDING

More often than not, gunfights were visceral spurof-the-moment encounters sparked by disagreements and fuelled by drink that bore little relation to the honour and romantic idyll of quick-draw.



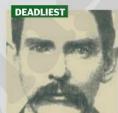
1. Billy the Kid

A renowned gunslinger he was not below tricking opponents to gain an advantage. On the wrong end of a battle of wits he was shot from the shadows by lawman Pat Garrett aged just 21.



2. Wild Bill Hickok

Hickok killed more than 20 me during gunfights; he would reload his 1851 Colt black powder revolver every morning (even if it hadn't been used) to prevent moisture and a resulting misfire.



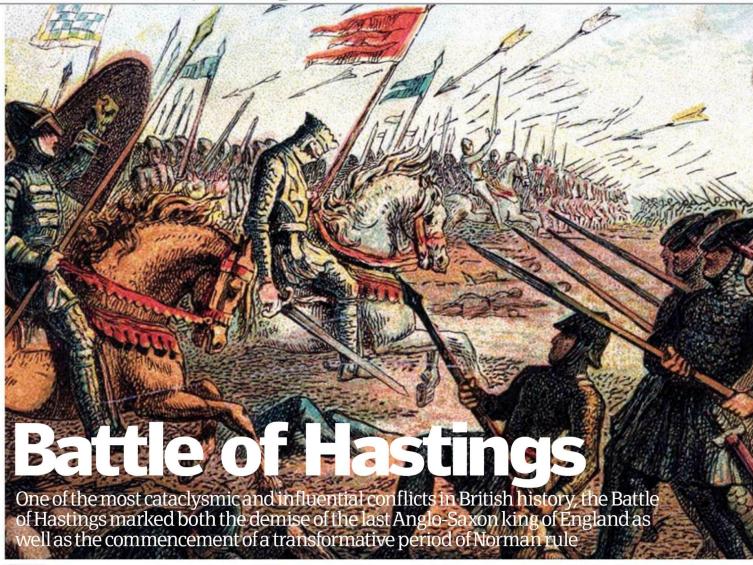
3. Doc Holliday

Wyatt Earp claimed Holliday was "the nerviest, fastest, deadliest man with a six-gun I ever saw! Earp lived to the ripe age of 81. Enough said.



For more information on the weapons that won the West, along with a detailed look at the history of arms and armour, the DK book Weapon, produced in association with the Royal Armouries Museum, is available from www.amazon.co.uk







The Battle of Hastings was the culmination of a fierce conflict over who would succeed Edward the

Confessor as the king of England. Initially this contest was between three potential heirs: Edward's cousin, Duke William of Normandy; Harold Godwinson, the most powerful man in England after Edward; and the Norwegian king Harald Hardrada. However, after Harold defeated Harald at the bloody battle of Stamford Bridge, there were but two potential candidates left.

This battle followed Harold declaring himself King of England, an act that incited William to invade, as he believed Edward had promised him the throne before his death.

Landing unopposed within weeks of the Battle of Stamford Bridge, William

then proceeded to march his troops
– consisting of men from Normandy,
Flanders, Brittany and France
(modern-day Paris) – towards London.
Harold, hearing of the landing and
advance, rushed his troops down the
country from Stamford Bridge (near
the city of York) to meet them in battle.

The two forces finally met just south of Senlac Hill, roughly ten kilometres (six miles) northwest of Hastings. King

Harold deployed his force astride the road from Hastings to London, his back to Senlac Hill along with the great forest of Anderida. Holding the higher territory, before the Anglo-Saxon troops lay a long, glacis-like slope that culminated in a low plateau. Upon this plateau William deployed his troops.

Tactically, Harold's troops deployed a shield wall – a formidable defensive

DEPARTURE

After hearing news of Harold's advancement on Hastings, William's knights are ordered to leave the city to do battle against the Anglo-Saxons.

The Bayeux Tapestry

Arguably the most important surviving record of the Norman Conquest, the Bayeux Tapestry records the Battle of Hastings in vivid, albeit probably biased, detail. Here's a translation of the Latin text...





Abbey

Today Battle Abbey stands on the location of the famous battle and is maintained by English Heritage. A plaque at marks the place where Harold is believed to have been killed.

A large part of Harold's army at the Battle of Hastings consisted of fyrdmen, untrained peasants drafted in a similar way as conscripts to protect their homeland.

According to historical report, the first man to be killed at the battle was William's jester, Taillefer, who after singing and juggling a sword, attacked the English shield and was killed.

Duke

CHILDREN

RELIGION

REIGN

PREDECESSOR

DEATH

William II

The Battle of Hastings is the first conflict where crossbows are recorded to have been used in English history. The crossbow originated in East Asia in the 4th Century BCE.

Christmas

William was crowned king on Christmas Day 1066 at Westminster Abbey. He deposed Harold's successor Edgar the Atheling who waged manyunsuccessful uprisings.

DID YOU KNOW? Norman cavalry was considered the best in the world during the 11th Century

setup where each soldier on the front ranks locked their shields together in order to mitigate attack by projectile weapons - with Harold's cavalry and standard behind, higher up the slope. William, on the other hand, arranged his troops with archers to the fore, infantry behind and with cavalry to the rear. This basic offensive arrangement signalled the start of the battle, which proceeded to last an entire day and culminated with the death of Harold (for a detailed stage-by-stage account of the battle see the 'Hastings battle map' on page 108).

William's victory at the Battle of Hastings heralded a landmark transition in the history of England and Britain in general. Ascending to the throne as King William I, the Norman Conquest began, leading to the vast majority of the ruling class of England to be displaced by Norman landholders, who monopolised all senior positions in the new government and Church. Further, due to William and his nobles all conducting court and administrative business in Norman French, the Anglo-Saxon language began to be phased out in key sections of society. Indeed, this sea change in language by the aristocracy - with Anglo-Norman increasingly favoured - still resonates today, with many French words adopted into the English language.

Ties to France and Normandy were also strengthened - something that the isolated island had in a large part lost since the collapse of the Roman Empire - leading to increased trade and monetisation of English produce such as wool. Administration on a national level was also modernised significantly, with articles such as the Domesday Book shedding light on areas of the country that were still operating in the Dark Ages and allowing taxation to transcend to a new level of efficiency.

These transitions were to lead England into a new era of financial power in Europe, which despite centuries of civil war and political intrigue, would see the country emerge as a world power in the Early Modern Era and beyond.

SCOUTING

Duke William quizzes a character called Vital whether he has seen King Harold's army in person. Vital proceeds to give William information on Harold's army.

DUKING IT OUT WITH A KING We pit the two key men of the battle head-to-head in the ultimate game of thrones... King Harold II 44 AGE (AT HASTINGS) Wessex **BORN** Anglo-Saxon LINEAGE

21 years (Earl) / 10 months (King)

King Edward the Confessor Battle of Hastings, England

8+

Orthodox Christian

Before ascending to the throne of England, Harold was a powerful nobleman and Earl of East Anglia, Hereford and Wessex. Aside from his aristocratic position. Harold gained power and influence through a series of successful military campaigns against Gruffydd ap

Llywelyn, the ruler of Wales.

Prior to the Battle of Hastings and his later crowning as king of England, William was Duke of Normandy, succeeding his father in 1035. Upon the death of King Edward the Confessor, Duke William was one of three claimants to the throne and, upon Harold's coronation, considered it an act of war and invaded.

38

Normandy

Norman

9+

Roman Catholic

52 years (Duke) / 21 years (King)

King Edgar II (uncrowned)

Rouen, France



PREPARATION

After gathering his troops, Duke William proceeds to encourage his knights to prepare themselves manfully and wisely for the battle against Harold's army



BROTHERS

As the battle commences, King Harold's brothers-named Leofwine and Gyrth-are killed in the fighting







While few historical records exist of the Battle of Hastings, through numerous second-hand sources a general picture of how it unfolded can be pieced together. Contextually, Harold approached the conflict three weeks after the Battle of Stamford Bridge, where he successfully repelled an invading Norwegian army led by King Harald Hardrada and his brother Tostig Godwinson. In contrast, Duke William approached the battle from a position of perceived betraval. being previously promised the English throne by Harold's predecessor Edward the Confessor. Upon hearing of Harold's coronation, William took it as an act of war and invaded England.

In terms of the battle itself, little information has survived on the numbers of men that composed both armies. Estimates - taken from a record of the number of ships that William supposedly brought to England (696) - indicate the Duke's force was 20,000 strong; however, any number between 3,000 and 30,000 can be argued on both sides. What is more definite is information on the position of the battle. Harold deployed his force astride the road from Hastings to London on Senlac Hill, roughly ten kilometres (six miles) northwest of the former city. Behind him and the hill lay the great forest of Anderida and to the fore the terrain sloped down to a plateau and further hill and forest. William's forces massed on the plateau, fighting from the disadvantaged lower altitude position.

To decode the battle map, consult the dual keys for troop type, movement and key events.

Unit guide Norman-French Standard: Twin leopards

of Normandy

Men: 3,000-30,000 (estimate)

Archers: White□

Infantry: Light blue Cavalry: Dark blue

Duke William II of Normandy:

Turquoise

Anglo-Saxon

Standard: Wyvern of Wessex

Men: 4,000-30,000 (estimate)

Archers: Yellow

Infantry: Light red Cavalry: Dark red King Harold: Burgundy



Drawing on the lessons of military history to postulate how King Harold might have claimed victory at the Battle of Hastings

Arguably Harold's actions in the run-up to and during the Battle of Hastings can be seen as a comedy of errors, which if some/all had been avoided, would have swung the probability of victory in his favour.

First, Harold approached the fight fresh from the brutal battle of Stamford Bridge, where thousands of his men were lost and those surviving exhausted. Second, upon hearing of William's invasion, he marched his men halfway down the country in an incredibly rapid period of time, tiring them

further. Third, instead of heeding his brother Earl Gyrth's advice that they should delay the battle in order to enlist reinforcements, he proceeded to close in on Hastings. Fourth, he ignored the possibility of outmanoeuvring William by holing up in London and drawing William into a costly siege. Fifth, after taking up an advantageous highly elevated position on the battlefield, lack of line discipline caused large numbers of men to abandon it chasing William's army in feigned flight attacks, leaving his shield wall exposed.

WAR

As the armies clash, men on both sides fall together in battle.

RALLY

Duke William's half-brother, Bishop Odo - depicted holding his baton encourages the Norman-French troops and rallies them during the fighting

STANDARD

Harold's personal standard is attacked and many men fighting with him are killed in the skirmish that ensues



"William's victory at the Battle of Hastings heralded a landmark transition in the history of England"

DIDYOUKNOW? King Harold was the last crowned English king of England

The countdown to victory

Follow the battle with this step-by-step report

1 pam – Harold positions his army on Senlac Hill, with his foot soldiers at the fore and cavalry at the rear. The infantry create a shield wall. In contrast, William positions his archers at the base of the hill, with infantry and cavalry behind them.

29.15am – William orders his archers to begin their assault, releasing a barrage of arrows at the Anglo-Saxon wall. The majority of the arrows are blocked by the shield wall and cause little damage.

3 9.20am – After the ineffectiveness of the archer assault, William then orders his archers to rejoin the infantry troops and then, en masse, charge the shield wall. The Anglo-Saxon force unleashes their own missiles on the Norman-French troops.

4 9.30am – Infantry clashes head on, with select cavalry units joining the fray from the rear. Fierce

battle ensues for over an hour and many men are lost on both sides. The Anglo-Saxon shield wall remains intact.

5 nam - Under the sustained pressure of the Anglo-Saxon shield wall, the left flank of the Norman-French forces are broken and forced to retreat down the hill. Anglo-Saxon foot soldiers pursue them, exposing William's flank.

6 11.15am – Rumour flies around the battlefield that William has been killed. To quash the rumour he removes his helmet and rallies the Norman-French troops. He proceeds to then take his standard and cut across the battlefield to cut off the Anglo-Saxon forces on his left.

7 11.30am - KEY CLASH William, along with his cavalry, cut off the pursuing Anglo-Saxons, forcing them to fight surrounded on exposed terrain. Meanwhile, Bishop Odo continues to rally the battling Norman-French troops.

8 1pm – After successfully defeating the Anglo-Saxon troops that had moved down the hill,



a break in the fighting ensues with the shield wall still intact and losses even on both sides. William then orders the attack to recommence.

9 3pm – After fierce fighting for much of the afternoon, the Anglo-Saxon shield wall still stands firm. William decides to switch tactics and orders his troops to undertake feigned flight tactics, hoping to draw parts of the wall down the hill.

4pm - KEY CLASH The feigned flight tactic works, drawing a central part of the shield wall down the hill. This exposes Harold and his cavalry, as well as forcing the remaining wall to contract in order to maintain form and structural integrity.

11 4-30pm – As the Anglo-Saxon infantry line contracts, gaps appear at the sides allowing Norman-French cavalry to attack from both flanks. William now has the upper-hand and Harold is in danger.

12 6pm+ - Harold's personal standard is attacked. He has already been injured in battle and, under the pressure of the assault, is hacked down by William's forces. Remaining Anglo-Saxon forces rout to the rear and William is victorious.

INTERVIEWDr Rebecca Rist



Dr Rebecca Rist is a lecturer in Medieval History at the University of Reading and is the author of numerous publications

about the medieval world, including *The Papacy And Crusading In Europe*, 1198-1245 (London: Continuum, 2009).

What impact did William's victory have on Britain?

William's conquest of England had enormous cultural impact. Aside from fostering a new, Europe-wide sense of cultural identity, the Normans also made England a trilingual society (Latin, Norman French and English), altered the cultural landscape by implementing new technologies such as building in stone – supported by technological developments in forest husbandry, metalwork and transport.

Did England benefit financially from the Norman Conquest?

In the long-term Duke William of Normandy's conquest was financially advantageous for England because it resulted in a reorientation of the country's traditional economic focus away from Viking Scandinavia towards the riches of north-west continental Europe. Trade with the European continent brought great economic and material benefits too.

If you were to offer one piece of advice to Harold prior to the battle, what would it have been?

I'd warn Harold that Hardrada would be invading England from the north in September and to ensure his troops got plenty of rest after the Battle of Stamford Bridge. If it was on the day of battle, I'd tell him not to pursue the Normans when they [feigned] flight, leading to ranks breaking.



DEATH

Here King Harold is slain and his remaining troops have turned in flight.

CONTROVERSY

It is unclear which character Harold is at the close of the tapestry, with the text indicating his death hanging above two dying characters. Traditionally it was believed that Harold was the character with an arrow in his eye; however, modern academic opinion believes he is actually the character being cut down by the Norman-French knight on horseback.



The Gunpowder Plot

Discover the history behind celebrating Guy Fawkes Night in the UK



Outraged by the continued suppression of the Catholic faith by the Protestant King James I, several schemes were

hatched to bring about his downfall and to restore a Catholic to the throne.

Early in his reign, in 1603, there was a plot to kidnap James to force him to abandon his anti-Catholic legislation. This so-called Bye Plot backfired and after the conspirators were captured and executed, James ordered all Roman Catholic clergymen from the country.

Guy Fawkes, who fought with the Spanish army and was an expert with gunpowder - together with Robert Catesby - had tried unsuccessfully to get Spain's King Philip II to support an invasion of England.

Their next plan of action was the Gunpowder Plot. The intention was to blow up the King and his supporters when they all attended the opening of parliament. After that, they would instal his nine-year-old daughter, Princess Elizabeth, as Queen of England. Later they would marry her off to a Spanish prince and secure England as a Catholic nation once more.

At first, the plotters planned to place the explosives under the House of Lords by digging a tunnel from a nearby rented house. As this project ran into difficulties, they took the opportunity to rent a coal storeroom in the House of Lords underneath the King's throne. Guy Fawkes hid the barrels of gunpowder in the room and had the job of igniting it at the right moment. However, he was captured red handed.

The 36 barrels of gunpowder were placed in position by July 1605 and were intended to be detonated on the opening of Parliament scheduled for the 3 October. This was delayed for a month



Sir Robert Catesby

Birth/death: 1573-1605

Bio: Born in Lapworth, Warwickshire to a prominent Catholic family. He studied at Oxford in 1586, but left to avoid swearing allegiance to the monarch. In 1593 he married Catherine Leigh who was a Protestant. In 1601 he was fined for being involved in the Essex Rebellion against Queen Elizabeth.

Guy Fawkes

Birth/death: 1570-1606

Bio: Born in York, he was educated at the Free School of St Peters. His father died when he was eight and his mother remarried a recusant Catholic. He became friends with Robert Catesby when he served as a footman to the 2nd Lord Montague. In 1593 he left England to enlist in the Spanish Army. He was nicknamed 'Guido' and was described as powerful and courageous





The Gunpowder timeline

24 May 1604 Thomas Percy, intent on reven

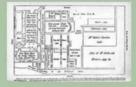
on the King, leases house nearto Parliament buildings



December 1604 Work starts on a tunnel to the House of Lords from the rented house.

March 1605

The tunnel is abandoned and a coal storeroom below the King's throne at the House of Lords is rented.





26 October 1605

An anonymous letter is sent to the Catholic Lord Monteagle warning him not to attend the opening of Parliament.

5 November 1605

King James I is shown the letter and soldiers search Parliament. They find the 36 barrels of gunpowder hidden awayalongwith the now-infamous Guy Fawkes





Operation Valkyrie

1 Claus Stauffenberg left a bomb hidden in a briefcase at a meeting with Adolf Hitler on the 20 July 1944. It killed three people, but Hitler evaded the full force of the blast.

Hit and miss

In 1962, Jean Bastien-Thiry led a group that machine-gunned the French President Charles de Gaulle's car as he rode through a Paris suburb. No one was hurt.

Targeting the Pope

Pope John Paul II was shot four times by Mehmet Ali Agca, in St Peter's Square, Vatican City. After the attack of 13 May 1981, the Pope forgave Mehmet and the two met in 1983.

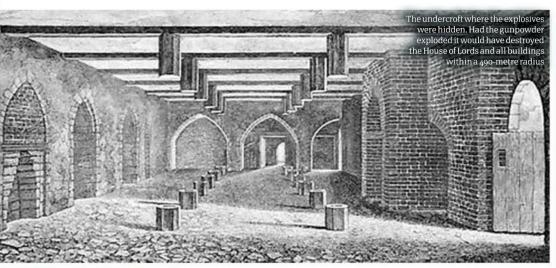
Remember to duck

4 John Hinckley III fired six shots at Ronald Reagan as he was leaving a hotel on 30 March 1981. After one bullet hit him, he told his wife: "Honey, I forgot to duck."

Beatle maniac

Michael Abram broke into George Harrison's home on 30 December 1999. He stabbed the former Beatle several times before he was knocked out by Harrison's wife.

DIDYOU KNOW? Some believe that Robert Cecil hated Catholics so much that he orchestrated the plot for his own ends



bubonic plague in the city. This meant that the gunpowder was slowly decaying, and it was declared fully separated into its component parts when it was retrieved and examined at the Tower of London magazine. This seems to indicate that if Guy Fawkes had lit the fuses, the only result would have been a pathetic splutter of fire rather than a huge explosion.

A documentary *The Gunpowder Plot:* Exploding *The Legend* tested what would have happened if Fawkes had actually lit

deteriorated gunpowder. It found that even a heap of such powder caused an explosion. When gunpowder is contained in barrels, it has even more explosive force, and causes a cannoning effect that blows the top off before the sides of the barrel blast out.

5 November marks the anniversary of Guy Fawkes' failure to destroy London's Houses of Parliament with 2,500kg of gunpowder. To celebrate the fact, people in the United Kingdom and some other British colonies around the world

> celebrate Guy Fawkes Night, often more commonly known as Bonfire Night. This annual event was introduced to celebrate the life of the monarch and remained compulsory till 1859. Today, the occasion includes a number of customs such as burning an effigy of Guy Fawkes on a bonfire and letting off fireworks to represent the possible explosion in 1605. Now you can not only remember remember 5 November, but you also know the story behind the celebration.

The plotters



The 13 people directly involved with the plot were well educated and came from aristocratic Catholic families – or had close connections with them. Like the plot's mastermind, Robert Catesby, they had all seen their parents and families suffer because of their faith.

At the Duck and Drake Inn, London in May 1604, Robert Catesby, Guy Fawkes, Thomas Percy, John Wright and Thomas Wintour pledged their support for the project. In the following year Thomas Bates, Christopher Wright, Robert Wintour, Sir Everard Digby, Francis Tresham, John Grant, Ambrose Rookwood and Robert Keyes were recruited into the conspiracy.

The victim



When ruling as the King of Scotland, James reassured Thomas Percy that the Catholic community would be safe when he came into power. On taking the English throne in 1603, James denied any such promises, and to make matters worse he introduced more laws against the Catholics. This fuelled Percy's hatred for the king and motivated him and the rest of the group to seek their revenge.



6 November 1605

Guy Fawkes states he worked alone to destroy the King and parliament. He is taken to the Tower of London and tortured in an attempt to discover the names of his partners in crime.

7 November 1605 Weakened by torture,

Fawkes confesses and supplies the names of his fellow conspirators.



8 November 1605

Robert Catesby, Thomas Percy and the Wright brothers are shot dead and the rest of the plotters are arrested.

30 January 1606Robert Wintour, Everard

Digby, John Grant, and Thomas Bates are hung, drawn and quartered in St Paul's Churchyard.



31 January 1606

The same fate awaited Guy Fawkes, Robert Keyes, Thomas Wintour and Ambrose Rookwood in Old Palace Yard next to the Houses of Parliament.





The cross bow A powerful and easy-to-use lethal weapon





A crossbow is basically a horizontal bow fitted with a

trigger mechanism. A stirrup at the front of the crossbow enables the user to hold it down with their foot as they pull the string back. The crannequin was developed to make it easier to draw the string. This consists of a crank attached to a toothed wheel that engaged with a ratchet bar. By turning the crank, the string is pulled back by the bar and held back by a trigger mechanism. After removing the crannequin a bolt or arrow can be inserted in a groove that runs along the tiller body of the crossbow.

Since the trigger mechanism keeps the bow cocked until it is released, it requires little strength to aim at a target compared to a longbow, where muscle power alone keeps the string taught and ready to fire.

5 TOP FACTS TYPES OF SWORD

Longsword

A type of sword commonly used in medieval Europe, between 1250 and 1550. The sword itself could have reached as far as 1.2 metres and weighed up to 2.4kg.

The small sword

The small, dress or court sword is famed for the decorative hilts and highly effective curved handles. It gained popularity during the 17th and 18th Century.

Japanese sword

A Japanese sword or nihont is one of the most recognisable weapons of Japanese culture. Most commonly known is the katana, used by samurai.

an

Jian are dual-edged
Chinese straight swords
(Dao are the single-edged
variant), and have been used
in the country for the past
2,500 years.

Flyssa

The flyssa is the traditional fighting sword used by the Kabyles tribe of Algeria and part of Morocco during the 19th Century. They varied in size from 12 to 38 inches.

DID YOU KNOW? The flyssa was famed for its ability to cut through chain mail armour



3

Medieval sword fighting styles were brutal and far less elegant than those associated with the Renaissance. However, it was the first time in

European history that a combat technique employed the art of self defence.

The fighting style was passed on from Italian and German training disciplines and encouraged blocking, increased attention to footwork, better

shield and armour protection as well as mastering the practice of counter cutting. Counter cutting was the technique of matching both offensive and defensive strategies in tandem and was intended to refine the rash rapier-orientated moves traditionally necessary for the battlefield.

The longsword was one of the most available weapons of the period, but only the aristocracy were permitted to own such a blade. It was often crafted to

lengths of 1.2m and weighed as heavy as 2.4kg. Displaying a long cruciform hilt, it could be held with both hands and introduced the medieval fighting style known as 'half-swording' where the fighter places one hand on the hilt and one on the blade to control the weapon. Other areas of combat that were common included fighting with daggers and pole weapons, fencing with a single-handed sword and buckler (a type of shield) and armoured fighting.

Hertz Horn

These lead protuberances

contain a glass vial filled

Naval mines

How do they work and what do you need to do to make them detonate?



Naval mines are a contact-initiated explosive that can either be moored to the ocean floor by steel cables or left free to drift around. Modern contact mines

work by encasing a large quantity of an explosive substance – such as TNT – in a spherical metal shell covered with hollow lead protuberances, each containing a glass vial filled with sulphuric acid. When crushed by the hull of a ship or submarine, these protuberances, known as Hertz Horns, cause the vial inside to break and the acid to run down into a lead-acid battery stripped of acid electrolyte. The mixing of the acid with the battery energises it, triggering the electronic detonator, causing the mine's substance to ignite and explode.

Damage rendered to vessels by contact mines is three-fold. First, the explosive substance will cause

direct damage – ie a hole in the hull will be blown open. This will cause severe damage to multiple watertight compartments and expose nearby crew to severe shrapnel debris. If the vessel is of small dimensions, an explosion of this type will likely sink it; if of large dimensions, it will cause it to become immobile. Second, when the mine explodes it will cause a bubble within the water, which – due to the difference in localised pressure – will collapse from the bottom. If this collapse occurs onto the ship's hull its force can puncture a metre-wide hole straight through the ship, killing all crew in its path instantly. Finally, contact mine explosions produce a shock wave that can cause any nearby vessel to resonate violently, causing engines to rip from their

housing cases of large ships and breaking smaller

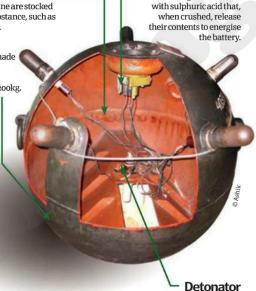
ones apart entirely.

Explosive

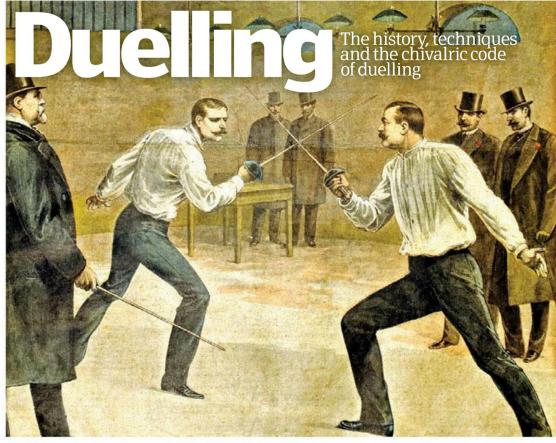
The innards of the mine are stocked with an explosive substance, such as TNT, minol or amatol.

Casing

The shell of the mine is made from a buoyant metal or plastic composite. They typically have a mass of 200kg.



Once powered on by the energised battery, the detonator ignites its primary material causing the explosive substance to detonate.





Duelling is intrinsically associated with the chivalric code of honour practised by medieval

knights. Although often linked with the royal courts of France and England, duelling is also known in the ancient world and is depicted in Greek and Egyptian iconography.

Guns at dawn

Duelling with pistols was dangerous and often resulted in serious injury. Participants employed prized single-shot flintlock pistols kept in pairs. No respectable Englishman travelled without his guns for protection.

The two men select a gun, which they held upright in their hand, and are asked to walk a short distance until they reached a marker in the ground. Here they would turn, advance and shoot.

When is it over?

Although the dishonoured party was able to stop the duel at any point it was often the drawing of first blood that ended the proceedings.

Once engaged, duellists rarely actually killed their opponents. Bound by a strict code of conduct, a gentleman would use the duel to defend his honour and demand satisfaction. A duel was proposed when an individual deliberately insulted someone of the same rank, or possibly to defend a woman's reputation.

Using blades

Various swords were used during duelling matches – the most common weapons being baskethilted swords. However, many gentlemen were trained with the rapier and short sword which were designed as thrusting weapons. The duellists used cutting and thrusting actions that enabled them to lunge at their opponent's body. The contestants aimed at vulnerable areas of the body, namely the neck and the thigh.

When is it over?

Before combat, the swordsmen often agreed to a code of practice. However, the code duello states that the duel must end when the opponent is 'well blooded'.

The time and place was arranged by a second appointed by each individual – they also agreed upon a suitable location. The duel would be undertaken in a remote area during the early morning or late evening, ensuring that the event remained unchallenged by the authorities and free from legal consequences if death ensued.

Other weapons

In ancient Egypt duels took place in temples as entertainment. The weapons used included sledgehammers, maces and chains. But the most dramatic duels took place in ancient Rome. The Retiarius was armed with a net and a trident, his only protection a shoulder guard. He used his weapon to create a distance between himself and his opponent. His attack was designed so that he could snare his opponent in the net.

When is it over?

Once the enemy was disabled or disarmed he would use the trident to puncture his neck. Duels could also be fought using daggers.

Duel legends

Legendary duel – pistols

The Burr-Hamilton duel involved two famous
American politicians. Aaron
Burr, who held the rank of
Vice President, shot and
killed Secretary of the
Treasury Alexander Hamilton
after the latter made a slur on
Burr's character.



Legendary duel – swords

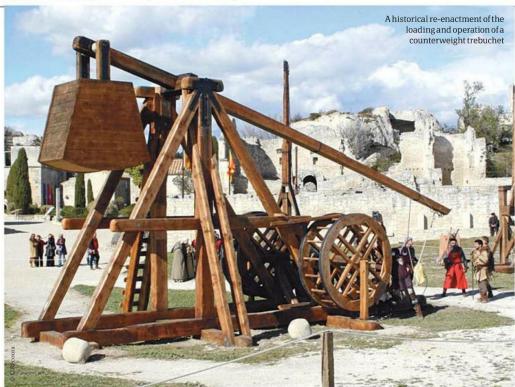
One of the most ferocious duels in history was that of Achilles versus Hector. After Achilles killed Hector with his sword, he tied the tendons of his heels to his chariot and ripped his body to shreds.

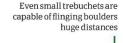


Legendary duel – in a hot-air balloon

In 1808 two Frenchmen, Monsieur de Grandpre and Monsieur de Pique, fought over a woman. Believing themselves to have 'elevated minds', they fought the duel in hot-air balloons. As they fired their pistols, one of the balloons burst, it fell to the ground killing the occupant.









Trebuchets

At the height of its power the trebuchet was an unstoppable force, crushing fortifications, buildings and men alike



The setting: King Richard's crusades in the latter half of the 12th Century. A counterweight trebuchet's arm and sling swing up

to a vertical position, releasing its housed projectile at a ferocious speed and power. The result? Twelve men crushed by a single, giant stone.

Built originally in the middle ages to bombard and besiege enemy fortifications and troops, the counterweight trebuchet was used as recently as 1600, the equivalent of today's long-range artillery cannons. Capable of launching objects of tremendous weight – including stone boulders, burning animals and even diseased human corpses used as an early form of biological warfare – over large distances, the counterweight trebuchet still to this day is a phenomenal feat of engineering.

Differing from the far earlier traction trebuchets, which relied on torsion and manpower, the counterweight trebuchet earned its reputation through the simplicity of its central design concept, relying on gravity alone to propel its ammunition further and more consistently than its predecessors. By

increasing projectile propulsion by relying on the mechanical advantage principle of leverage, rather than that of torsion and manpower, for centuries the counterweight trebuchet laid waste to city walls and fortifications worldwide.

A counterweight trebuchet consists of five basic parts; the frame, guide chute, beam, sling and counterweight, which in order to propel an object must all work in harmony. Supported by the frame – which provides the all-important raised position needed for this gravity-reliant system – the counterweight is dropped which in turn rotates the beam and attached sling. The sling, which is guided along the chute until critical acceleration is achieved (therefore keeping the projectile in the sling), then reaches a near vertical degree before releasing its contents.

While historians still argue to this day about the precise details of early counterweight trebuchets – such as their numbers, design and origin – one thing is definitely clear; it was most certainly a weapon of epic proportions giving whoever wielded it a considerable advantage in any siege.

How it fires... The trebuchet firing 4. Release mechanism explained Ata near vertical degree, critical acceleration is achieved and the 3. Boulder load is released. At maximum extension the sling leaves the ground under the huge generation of upward motion 2. Sling Once the counterweight is dropped the 1. Counterweight beam accelerates quickly. Momentum for the trebuchet's dragging its sling with it along beam and sling comes courtesy a guidance chute. of its heavy counterweight.



Inside a gun turret

These structures can soak up hefty damage while dealing out awesome firepower



Agun turret works by protecting the crew or computer mechanism of a projectile firing weapon,

allowing it to operate with greatest freedom and safety. Gun turrets are often mounted on fortified buildings such as anti-naval land batteries - or on military-grade vehicles such as APCs and aircraft carriers.

The turret itself can house a wide variety of armaments, often consisting of machine guns, automatic cannons, large-calibre guns or missile launchers, and is either controlled manually by its human crew or remotely by computer systems. One of the best modern-day examples of gun turrets can be seen on battleships, which have the largest cannons and the most sophisticated loading mechanisms.

Armoured gun house The part of the turret that features its weaponry. This

is the most exposed and therefore heavily armoured section of the structure.

Powder hoist Projectile hoist The element

dedicated to lifting

explosive substance

and loading the

into the cannon.

The ammunition of choice often large-scale explosive shells-is hauled up from the projectile handling floor by this lift mechanism.

Machinery

This is where the majority of the turret's mechanical machinery is located.

Powder handling floor

As with the projectile floor, the olosive substance used to propel the missiles must be manually

loaded and this occurs here.



Deck lug

Supporting the turret's cannons, the

incrementally adjusted depending on the range of the target.

The roller path dictates the degree of

rotation possible by the gun house

lug enables the guns to be

The barbette is a protective circular armour that surrounds the

Roller path

Magazine

An area dedicated to ammunition storage.

Turret foundation

This is the stationary part of the turret that provides it with a platform from which to rotate and absorb its blast shocks.

Projectile handling floor

Agun this size is mostly automatic, however crew-members are still required in most cases to transfer the ammunition from the magazine to the projectile hoist manually.

Torch-hole

116

Gunpowder or a fuse is placed in the torch hole and ignited to fire the cannon.

Gunpowder

In the late-15th Century water was added to gunpowder to form granules or mill cakes, making it easier to store and more efficient.

e canno

The weapon that changed the nature of warfare



Early cannons were crude affairs with barrels made from wooden or wroughtiron staves held together by iron hoops. If the explosive mixture was too powerful it

was likely to destroy the weapon rather than fire a projectile at the enemy.

Barrel-making techniques were replaced by bell-making technology, with the production of cast brass cannons. Improvements in the casting of bronze cannons in the mid-14th Century meant that more powerful gunpowder mixtures of sulphur, charcoal and saltpetre could be employed with more deadly effect.

In the mid-16th Century, the development of cast iron cannons brought down the cost of production and enabled an even wider deployment of this powerful weapon.

The use of cannons meant that castles and fortified buildings were no longer able to withstand long sieges. Large and complex star-shaped fortifications were introduced to cope with this danger; this had the effect of centralising power as only the richest could afford them.



Cannonball

Spherical, solid cannonballswere made from dressed stone, lead or iron.

Ramrod

When loaded, the ramrod is used to pack the wadding and cannonball firmly against the gunpowder. If not packed properly, the powder will burn instead of exploding.

Wadding

Hemp oakum wadding rammed into the barrel either side of the cannonball keeps it firmly in position



forts

Providing invaluable defensive strongholds, hill forts were a common feature of Bronze and Iron Age Europe



Hill forts were raised defended settlements, often built on cliff tops or large knolls and spurs, that

provided trading centres and secure enclosed habitats for people during the Bronze and Iron Ages. Their construction came to a peak in Britain during the last 500 years BC, where numerous improvements were made to their defensive structures – such as extra lines of earthworks, stockades and defensive walls – due to the multiple invasions the country was subjected to that culminated in the Roman occupation from AD 43 onwards.

Many hill forts have their origin in the Neolithic period and were originally not used as centres of trade and dwelling but instead to pen and protect agricultural animals, which were an invaluable source of both food and drink to the people. During the Bronze Age hill forts evolved to include roundhouses, longhouses and granary huts, as well as underground souterrains and fogous (underground cave structures used for food storage and preservation), before becoming more military focused through the Iron Age with guarded entrances, guard houses and ramparts integrated into them.

Indeed, the main structure that characterises most hill forts is its ramparts. These large man-made mounds of rock, wood, earth and dead animals, served as valuable fortifications against any attacking forces and created a series of ridged circular ditched rings that proved difficult to circumvent. These

fortifications were hardly impregnable however, and a number of invading forces – such as the Belgic invasions of Britain in the 1st Century BC – took many of them under sustained pressure and either inhabited them themselves, or burnt and sacked them. Instead, the native Britains and Europeans relied on the natural positioning of the fort to repel invaders.

The largest and most complex of all Iron Age hill forts in Britain is Maiden Castle, located in Dorchester, Dorset. This large raised hill fort was first laid out back in 600 BC over the remains of an earlier Neolithic settlement. Its multiple rampart enclosure is larger than the area of 50 football pitches and at its peak this colossal fort housed over 700 people.

5 TOP FACTS HILL FORTS

Ye olde

The 'golden age' for hill fort construction was between 500 BC and AD 50.

Widespread

There are the remains of over 2,000 Iron Age hill forts in Britain today.

Defensive

Alfred the Great built a series of hill forts along the coastal hills of Wessex to guard against Viking attack.

Habitable

The hill fort of Old Sarum was lived in up till the 19th Century.

Heritage

Maiden castle, an Iron Age hill fort once occupied by the Celtic Durotriges tribe, is now protected as a Scheduled Ancient Monument.

Attacking and defending and defending acastle Castle Offence Ballista Asiege weapon created by the ancient Greeks and then

Taking a well-fortified castle was an epic undertaking for any army, requiring vast manpower and a host of siege weaponry, and defending one was equally challenging

Before the advent and proliferation of gunpowder, castles were the greatest defensive structures on Earth.

From antiquity to the close of the Middle Ages, castles provided seemingly impenetrable structures of metal and stone that not even the sharpest blade nor arrowhead could breach. Further, they provided their occupiers with a whole host of attacking tools and features that made decimating an attacking force easy, as well as the space and time to hold out for reinforcements. If history has taught one thing, however, it is that castles were not impregnable, with epic confrontations bringing the demise of even the most well-fortified of structures.

To deal with this Herculean task, a new form of warfare was developed: siege warfare, a costly and complicated series of intricate tactics and complex siege weaponry. In many regards - as is usual when humans pursue acts of war - the results were both marvellous and brutal in equal measure. Maniacal machines constructed from wood, metal and animals allowed those seemingly impenetrable walls to be scaled and broken, soldiers to be impaled by metre-long spears over great distances and flaming canisters of liquid fire to be hurled into the heart of the enemy's encampment. Soon these fortresses of safety and solitude became potential tombs for their occupiers, requiring castles to evolve in order to address these formidable new threats.

Here, we break down a typical castle siege, highlighting the key offensive and defensive tools, tactics and weaponry that decided these epic encounters.

Offence Trebuchet

The most popular siege engine conceived during the Middle Ages, the trebuchet allowed huge boulders and flaming corpses to be sling-shot into and over castle walls. If the boulders didn't crush the men inside, then the flaming corpses would set fire to buildings and spread disease.

"To deal with this Herculean task, a new form of warfare was developed: siege warfare"

Offence Siege tower

The siege tower provided attackers with a viable and protective climbing platform to scale castle walls. A rectangular wooden structure mounted on four wheels. the tower consisted of multiple scaffold-like platforms with a top-mounted bridge. This technology was developed in the Neo-Assyrian Empire of the 9th century.

Offence Sapping

A process of digging a trench underneath castle walls and placinggunpowder underneath, sapping allowed attackers to breach defensive fortifications with high explosives. This tactic became commonplace after the 14th century due to advances in gunpowder formulation. This tactic was used in the month-long siegeof Godesberg in 1583.

Defence Moat

improved by the Romans, the

launcher. By twisting torsion springs made from animal sinew over a wooden bow and frame, large iron spears

could be launched at groups

and a great range.

of men at both a high velocity

ballista was a torsion

spring-powered missile

Arguably the second greatest deterrence of any castle, after its walls, the moat presented attackers with a recessed barrier of water that was costly to cross. In addition, siege engines such as the siege tower could not be used and avenues of attack were severely restricted. Sapping tactics were also restricted.



5 TOP FACTS THE RESTE & FALL

Antiquated

While all but impregnable in classic and medieval times, the age of the castle came crashing to a halt in the late 15th century with the arrival of heavy firearms, such as cannons.

backwards and forwards.

Aristocracy

2 Despite losing their role as fortifications, castles and similar structures were popular up to the 19th century, adopted and maintained by the rich as family homes.

Arson

One of the most damaging forms of offence was fire. Flaming arrows and burning corpses hurled over the walls could set both buildings and wooden siege weapons alight.

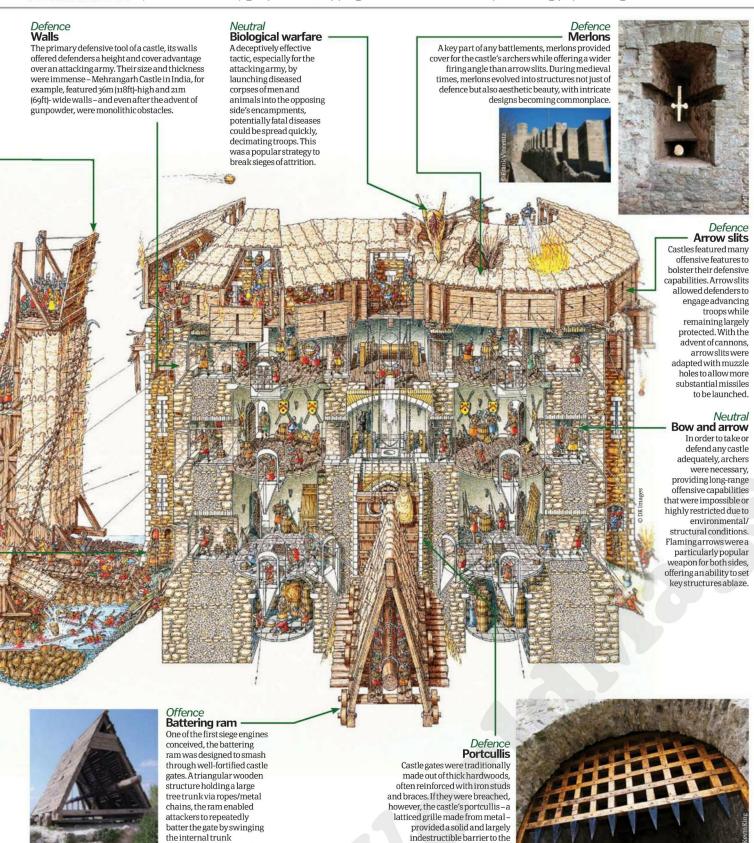
Architecture

With the arrival of cannons, castle architecture changed drastically. Star forts offered better defence against cannons but at the cost of civil and administrative functionality.

Longest

The longest castle siege to have taken place in Britain was the Siege of Harlech, which lasted between 1461 and 1468 during the War of the Roses. This siege is commemorated in the song *Men Of Harlech*.

DIDYOUKNOW? After the advent of gunpowder, sapping castle walls became a particularly popular siege tactic



internal courts and fortifications.

Mark I tank

Created as a solution to trench warfare, the Mark I tank heralded a new era of armed conflict



The world's first ever combat tank, the Mark I has been entrenched in military history and the human consciousness

for reasons both good and bad. With its unique rhomboid-shape design, progressive adoption of caterpillar tracks and ability to deliver massive firepower and armour in a mobile unit, it is celebrated as a great technical achievement that broke the domination of trench warfare.

However, it is also remembered as the invention that led many men to die in the most horrendous of manners, both enemy and ally alike, either mown down by its awesome firepower, or entombed in its hot, smoky innards, incinerated when its armour was breached. Technically, for the time its design and mechanics were revolutionary, but they came at the cost of an additional fatal separation between cause and effect – no longer were battles fought between men, they were fought between men and machines.

The Mark I was powered by a Daimler six-cylinder, 13-litre capacity engine. Despite its large size, however, the engine was only capable of producing 105 brake horsepower and despite it being chosen for its reliability, because it was fitted in the same compartment of the tank as the rest of the crew, the fumes, noise and heat it produced made conditions incredibly challenging. The engine was initiated by four members of the crew winding a huge crank handle (similar to those on early fighter planes) and was cooled by water.

As for weapons the primary, male-variant of the Mark I was mounted with two six-pounder naval guns, one in each sponson (rotatable turret-like structures on its sides), as well as three light machine guns. The lighter female variant of the Mark I was fitted with two heavy Vickers machine guns instead of the six-pounders. The Hotchkiss six-pounder naval guns had a range of 6,860 metres and were aimed with basic telescopic sights by their gunners. Each Mark I carried 334 shells.

In terms of defence, the thickness of the Mark I's armour varied over its chassis. In crucial areas such as the front for example, it was 10mm thick, however elsewhere such as the rear, it was only a slight 6mm thick. This meant that while the tank could not be breached by small arms fire and shrapnel,

any direct shell or mortar hit would likely breach its resistance threshold. As the First World War progressed, however, the creation of harder, armour-piercing bullets reduced the effectiveness of the armour.

Controlling the Mark I was an epic task, requiring four crew members working in unison. One driver operated the brakes, the other driver meanwhile operated the primary gearbox. Track control was then independently operated by the unit's two gear men. Compounding this was the fact that inside the tank the noise of the engine was deafening, meaning that communication had to be conducted using both sign language and Morse code.

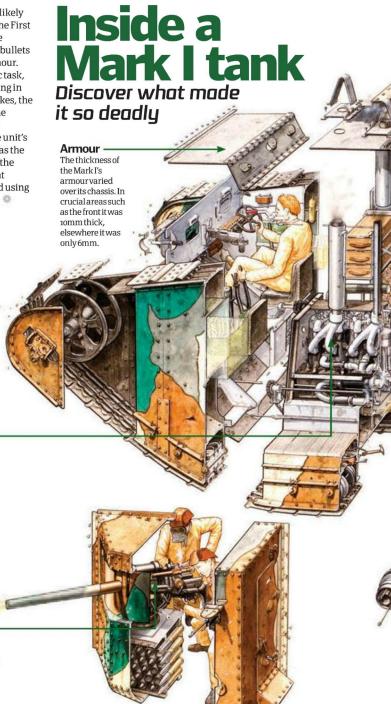


Engine
The Mark I was fitted
with a Daimler sixcylinder, 13-litre capa

cylinder, 13-litre capacity engine. Despite its size, the engine was only capable of producing 105 brake horsepower.

Guns

The primary, male-variant of the Mark I was mounted with two six-pounder naval guns, one in each sponson, as well as three light machine guns.



5 TOP FACTS MARK I TANK

Gender

There were two different types of the Mark I. There was the primary male variant, which was heavier and armed with dual cannons, as well as a lighter female version.

Risky

Communication between tanks and command posts relied on carrier pigeons – who had their own small exit hatch in the tank – as well as runners.

Salvage

The Mark I was susceptible to mortar fire as its fuel tanks were fitted high up in the cabin. These hits caused crews to be incinerated in the resultant blast.

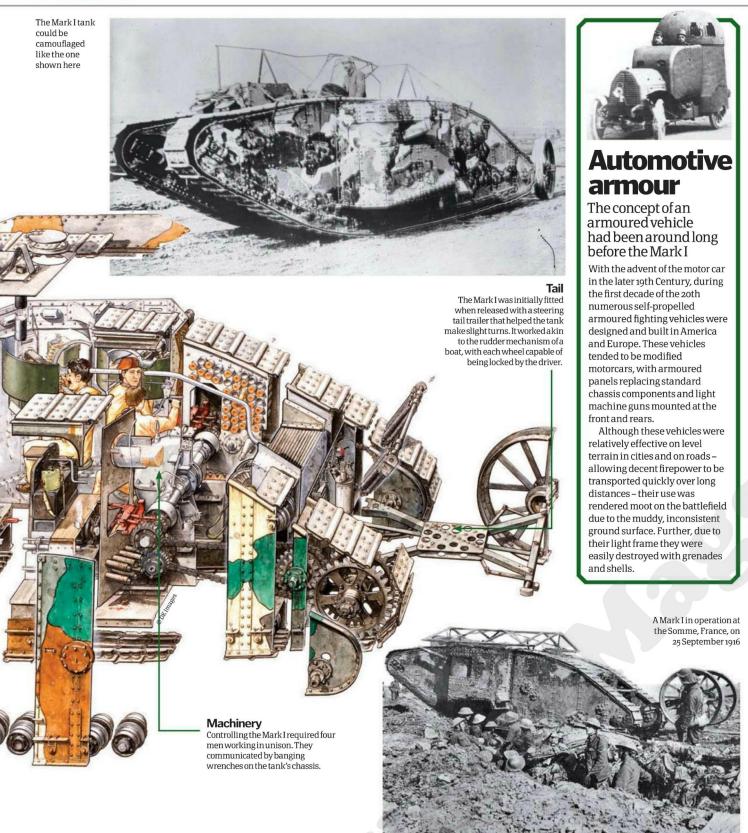
aıl

In order for the Mark I to make slight turns it required the help of a steering tail, a dual-wheel trolley that when operated correctly would help turn the tank.

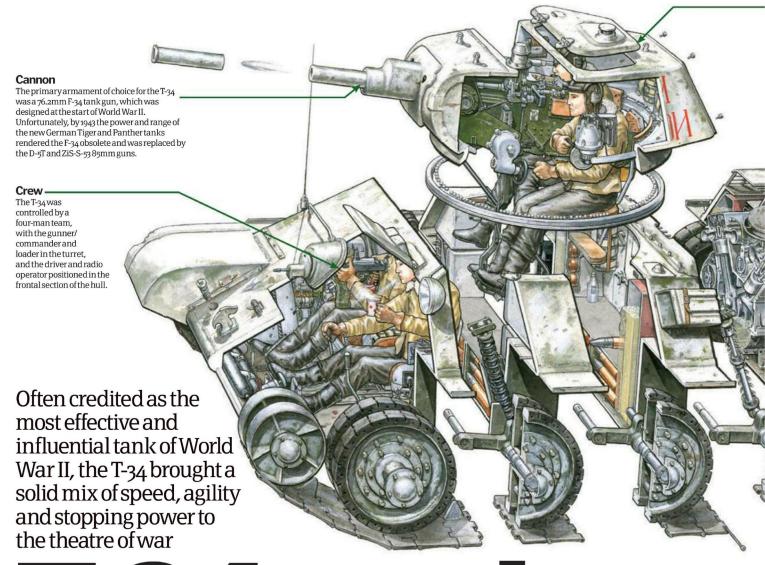
Noxious

The design of the Mark I placed the crew in the same compartment as the engine. Not surprisingly this led to an extremely hot and fume-heavy environment.

DIDYOU KNOW? The prototype of the Mark I was nicknamed 'Mother'







T-34 tank



One of the most numerous armoured vehicles during World War II, the Soviet Union's T-34 medium tank is considered by military historians to be one of the most important and

influential tanks ever to be built.

Evolving out of the BT series of fast tanks (Soviet cavalry tanks with thin armour and high mobility), the T-34 at its introduction was the first tank to sport a complete balance between firepower, mobility, protection and longevity – something that modern tanks now take for granted. Further, it was an especially refined and simple design that

allowed for costs (135,000 rubles) and production time frames to be kept low, meaning that many tanks could be produced in very little time and allow Russia to mitigate its higher-than-average losses quickly and cheaply. Indeed, this became a very important factor towards the end of the war when the superior – but hard and expensive to manufacture – German Tiger and Panther tanks could not be replaced fast enough.

The T-34 was fitted with a good balance of weaponry, sporting a 76.2mm F-34 tank gun – ideal for taking down medium and light armoured enemy vehicles – and twin 7.62mm DT machine

guns, perfect against unarmoured targets and to suppress waves of advancing soldiers. Its armour also offered a great balance between protection and weight, with up to 63mm of armour plating standing between its crew and the shells and bullets of the enemy.

This meant that only the largest of enemy cannons – such as the 88mm beast fitted to the German Tiger tank – could breach its hull or turret and, considering its high top speed of 33mph, this was only possible if it became entrenched or caught unawares. By keeping the armour thickness to a medium level though, the total weight of the T-34

5 TOP FACTS T-34 TANK

Numerous

1 From 1940 to 1958 a total of 84,070 T-34s were produced, running through five different design variants and operated in over 20 countries across the entire globe.

Ukrainian

The T-34 was primarily built at the Malyshev Locomotive Factory in Kharkiv, Ukraine. The factory was named after Soviet politician Vyacheslav Malyshev in 1895.

ocal

Many T-34s still exist today, including those that have been decommissioned. An example can be found at the corner of Mandela Way and Pages Walk in Bermondsey, London.

Bazaar

The going rate for a working T-34 is \$30,000 and can be often bought in demilitarised auctions. Apart from Third World militaries, most T-34s are privately owned.

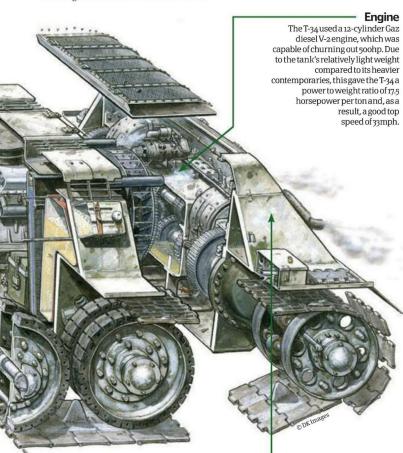
Bog

The latest T-34 to be recovered was a 1943 model, found at the bottom of a bog in Estonia. The tank had been captured and dumped by retreating German troops.

DIDYOU KNOW? Two T-34s were made to resemble German Tiger tanks in the movie Saving Private Ryan

Turret

The T-34 used a two-man turret crew system where the tank's commander also served as the gunner. This was common in Soviet tank designs during World War II, despite three-man turret crews proving superior in the field. Later models of the T-34 expanded the turret ring to allow for three-man turret crews.

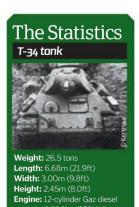


Armour

The 1941 variant of the T-34 was equipped with 45mm front and side hull armour, 60mm turret armour and 63mm side armour plating. This provided superior protection for its crew than its predecessors – the BT-5, BT-7 and T-26 – however, heavy tanks such as the German Tiger could still easily breach it.

was kept down to 26 tons, under half that of the German Tiger and allowing the T-34 unrivalled dynamism in the field.

Historically, the T-34 will be remembered as the vehicle that swept German forces from Russia, advancing from Stalingrad all the way to Berlin in 1945. However, its usage continued right up to 1958, when it was finally replaced by its successor the T-54. Despite its official retirement however, the T-34 has continued to be used in Third World militaries right up to the present day and has also found itself bought and operated by both private collectors and military museums.

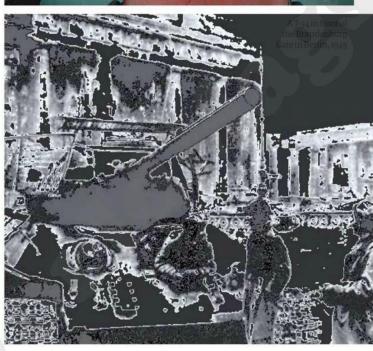


Max range: 250 miles (400km)

Max speed: 33mph (53km/h)









Commander Responsible for the tank's welfare, positioning and activity, Tiger Commanders were experienced Commanders were experienced Commanders were experienced

The German heavy tank of choice during World War II, the Tiger was a formidable adversary, bringing massive armour and firepower to the theatre of war

In order to shift the tank's huge weight (56.9 tons), a Maybach HL230 P45 V-12 petrol engine was installed at the rear of the Tiger.



Gunner

Operating the Tiger's monster gun, the





Side/rear hull armour Weaker and thinner than the armour at the front of the tank, the walls of the side hull were 2.4 inches thick or less.



Along with the Panzer, the Tiger is one of the most iconic German tanks of the Second World War. A monster conglomeration of metal and man, built to puncture holes in allied

forces from the snowy plains of Russia, through the rolling countryside of France, to the dusty desert plains of North Africa, the Tiger was feared and rightly so, as it was an efficient and powerful killer. It was armed with a 8.8cm main gun, capable of firing rounds that not only tore through enemy armour but also carried highly explosive tips which literally ripped man and machine in two.

On top of all this, it also sported armour that was impregnable at wide firing angles and distances and was driven by commanders who had already proved themselves in warfare. It was due to these attributes that Tiger tanks accounted for thousands of allied kills.

Central to the Tiger's success was the radical change in its design philosophy. Switching from the traditional all-rounder designs of earlier German tanks, the Tiger was built with a focus on massive armour and firepower at the expense of manoeuvrability. This gave the Tiger the stopping power to pierce any armour the allied forces brought

to the field of war, while also greatly minimising the probability of having its own armour broken. In fact, with 100mm (3.9") frontal hull armour, as well as the basically impregnable 120mm (4.7") frontal turret armour, attempting to take on a Tiger from the front was almost impossible. Indeed, historically in order to take out a Tiger allied forces were often forced to flank it so they could target the weaker side and rear armour, as well as getting as close as possible to maximise the chance of piercing it.

On the other hand, the firepower that this new breed of tank gave the German forces meant it didn't need anywhere near that level of refinement in order

Head to Head BATTLE TANKS



1. Tiger
Twice as long in production than either the M26 or losif Stalin, the Tiger was one of the most technically advanced, and deadliest, tanks of the age.



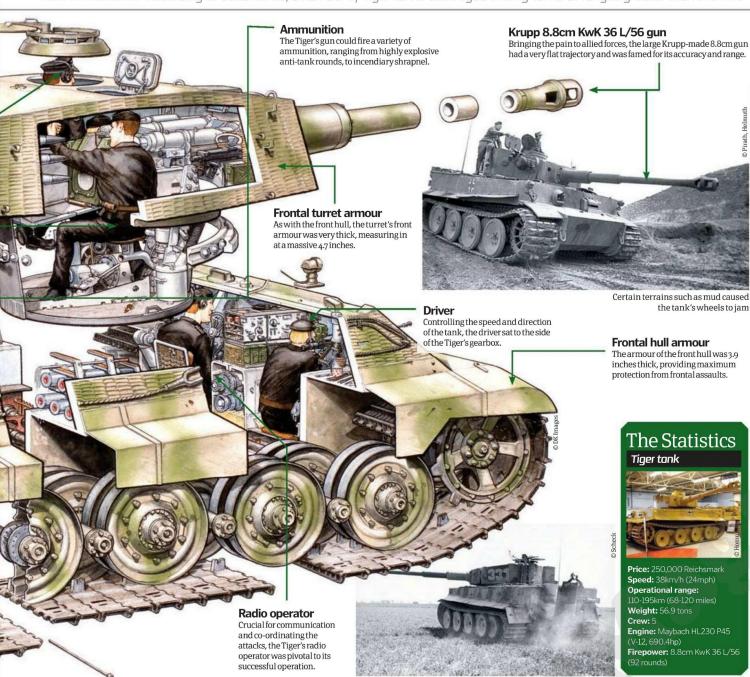
2. M26 Pershing
The American counterpart to
the Tiger, the M26 Pershing
was produced during WWII. It
was lighter and quicker than the
Tiger, with an impressive M3
90mm qun.



3. losif Stalin

The Russian equivalent of the Tiger, the losif Stalin evolved through numerous iterations throughout WWII. The tank sported a massive D25-T 122mm gun and was very light.

DIDYOUKNOW? According to documents, a number of Tiger tanks destroyed enemy tanks at ranges greater than one mile



to score a hit. The Krupp-made 8.8cm KwK 36 L/56 gun allowed German gunners to hit targets well over 1,100 metres away no bigger than 50cm². In fact, reports from the time indicate that Tigers took out numerous allied tanks at a range of over a mile (1,600 metres), thanks to their gun's flat trajectory and expulsion of rounds at high velocity. Ammunition types could be varied too, allowing the gunner to load the Tiger's main gun with rounds to suit most situations, be that highly explosive anti-tank shells, armour piercing rounds or anti-infantry incendiary shrapnel rounds.

Of course, as we know from the unfolding of history, the Tiger's dominance was short lived. This was due to

multiple factors but mainly stemmed from its costly production – limiting the amount of units that were actually produced compared to its contemporaries – and also its poor mobility over certain types of terrain. Indeed, the Tiger was often too heavy for bridges and therefore had to drive through shallow rivers and gullies, a dangerous process considering the fragile nature of its multi-wheel, interlapped design, as in cold weather water, snow and mud often jammed them badly. Of course, the final nail in the T-34's coffin was at the close of the war, when much of Germany's armaments were destroyed post defeat.



Most Tiger tanks are now decommissioned and reside in museums





The Churchill tank typically operated with a five-man crew

Churchill tank

The most successful British tank series during World War II, the Churchill was a defensive powerhouse and a versatile weapons platform



Designed in the aftermath of the evacuation of Dunkirk by the British Expeditionary Force, the Churchill tank was Britain's

attempt to readdress the technology gap between their ageing Matilda II battalion and the German Panzer tanks that had them outgunned. The result was the Mark I, a heavily armoured battle tank equipped with a twopounder main gun, three-inch howitzer in the rear and the most advanced and robust suspension system yet conceived. It was a defensive juggernaut, designed with one goal: to dominate the European theatre of war.

From its introduction in June 1941, the tank proved a reliable and versatile weapon platform capable of engaging targets quickly and efficiently. Key to this was its high speed of 26km/h (16mph) and excellent turning ability, characteristics made possible by its multiple-bogie suspension system. The suspension was fitted to the hull under two large pannier enclosures on either side, with the tracks running over the top.

The tracks moved over a series of ten-inch wheels, which themselves were fitted to 11 bogies (a wheeled framework) on either side of the vehicle. The suspension took the main weight of the Churchill tank on nine of its 11 bogie pairs, with the front set used when nosing into the ground on steep terrain and the rear set used as a track tensioner. Due to the sheer number of wheels and wrap-roundpannier tracks, this allowed the Churchill tank to operate even when parts of the system

were damaged in combat, keeping the tank moving and operational.

Due to the weight of the Churchill's armour plating, a massive powerplant was necessary to keep it moving at speed. This power came courtesy of a Bedford Vehicles horizontally opposed twin-six petrol engine, which could produce 350bhp at 2,200rpm and delivered 960 pounds of torque. The engine was controlled through a Merritt-Brown gearbox with an inbuilt regenerative breaking system. This allowed the tank to be steered by changing the relative speeds of the two tracks and, when put in its lowest gear, perform a neutral turn on the spot. This ability to turn so rapidly earned the Churchill much praise and made engaging moving targets considerably easier than in previous models.

Initially, the Churchill was fitted with a twopounder main gun and three-inch howitzer (artillery piece); however, the former was soon upgraded to a six-pounder cannon and the latter replaced with a high-calibre machine gun. These cannons gave the Churchill decent stopping power against medium armour, yet still left them short in firepower when compared with their German contemporaries. The Churchill's main cannon continued to be improved throughout its lifespan, with 75mm guns fitted to Mk IIIs.

Despite its average firepower, however, the Churchill's high manoeuvrability and excellent armour made it one of the foremost tanks of WWII, being extensively deployed in Europe and North Africa.

which was housed in a composite turret. The gun allowed the tank to engage German armoured vehicles and buildings, but lacked $the\,penetration\,against\,heavily\,armoured$ $targets.\,Machine\,guns\,and\,even\,flamethrowers$ were attached to other models.

 $The\,Mk\,VII\,was\,armed\,with\,a\,75mm\,cannon,$

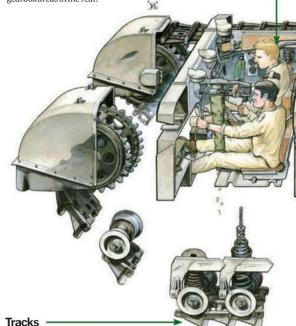




Armament

Crew

The Churchill was operated by five crew, consisting of a commander, gunner, radio operator, driver and co-driver. These inhabited four separate compartments within the hull, with the driving position located at the front, fighting compartment in centre and engine and gearbox areas in the rear.



The Churchill was fitted with an advanced suspension system based on 11 bogies on either side, each carrying two ten-inch wheels. The vehicle's weight was taken by nine of the pairs at any one time, with the front pair used when no sing into the ground and the rear pair as a track tensioner.

Outgunned

Most Churchill variants were outgunned by their German counterparts, unable to match the range and penetration. However, their super-thick armour compensated for this.

Normandy

The Churchill was one of the primary tanks used in the famous Normandy Invasion, and went on to help ensure Allied success across
Northern France and Germany.

The Mk I and Mk II featured in the Allied North Africa campaign, going head to head with the German Panzers. The Churchill's manoeuvrability helped dominate the terrain.

Funnies

The specialist vehicle variants of the Churchill were nicknamed 'Hobart's Funnies' by Allied soldiers. The name is taken from their commander, Major-General Percy Hobart.

Operators

During its life span the Churchill was operated by several independent nations including the United Kingdom, Australia, Canada, Ireland and the Soviet Union.

DIDYOU KNOW? The Churchill tank was named after British prime minister Winston Churchill



Blowing the lid off the Churchill Mk VI

We breach one of the most successful Churchill variants to discover what made it so ruthless, reliable and iconic





The statistics...

Churchill Mk IV

Crew: 5

Armour

The Mk VII was nicknamed the

protective armour. Its hull was

thick at the sides and 5.1cm thick

at the rear. The turret was 15cm

350bhp at 2,200rpm. The average speed of the

the Mk I due to increased armour thickness

Churchill Mk VII was 12.7mph, significantly less than

14cm thick at the front, 5.7cm

'Heavy Churchill' for its

exceptional weight and

thick at the front.

Weight: 38.5 tons

Length: 7.44m (24ft 5in)

Width: 3.25m (10ft 8in) Height: 2.49m (8ft 2in)

Engine: Bedford twin-six petrol

(350bhp at 2,200rpm) Power/weight: 9.1hp/tonne

Max range: 90km (55mi) Max speed: 24km/h (15mph)

Learn more

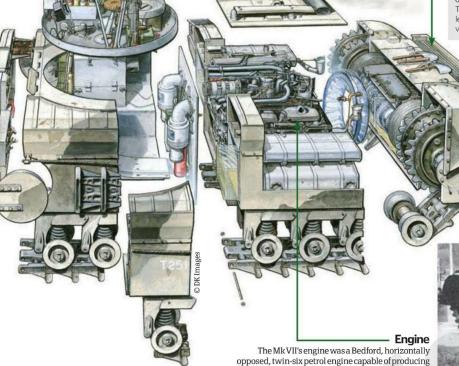
In Association with The Tank Museum

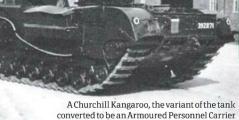
With over 200 of the world's finest tanks on display in six large halls and with action-packed live displays and special events, The Tank Museum is a great place to learn about armoured fighting vehicles. Visit tankmuseum.org.

Maximum versatility

From bridge layer to mine clearer. the Churchill tank was the ideal base for a host of specialist vehicles

Due to the Churchill's high manoeuvrability and advanced suspension system, it made a natural base for a number of specialist vehicles. Some highlights include the Churchill Crocodile, a variant of the tank that was fitted with a flamethrower for antiinfantry operations; the Churchill ARK, an armoured ramp carrier that could make mobile bridges to cross water hazards and difficult terrain; and the Churchill AVRE, a multi-use vehicle equipped with mine flails, Fascine rollers, explosive placers and a 290mm Spigot mortar for levelling buildings. In fact, the Churchill proved so versatile that late on in the war it was even converted into an Armoured Personnel Carrier (APC), with engineers removing its turret completely. This variant was called the Churchill Kangaroo, (see photo below).







Willys Jeep

The most iconic light transport vehicle of World War II, the Willys jeep was versatile, manoeuvrable and fast over uneven terrain

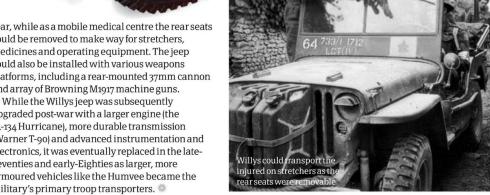
The first and most distinctive jeep ever built, the Willys jeep was designed in 1940 as part of a competition to provide the US Army with a new light transport vehicle for the impending World War II. It dictated light transport vehicle design for decades to come, only being phased out in the late-Seventies. Light, adaptable and highly manoeuvrable, the Willys jeep in its various forms (MA, MB and post-war M₃8/M₆06) allowed allied forces to transport troops, munitions and injured soldiers to and from the front line quickly and efficiently.

Central to its effectiveness was its L134 2.2-litre engine, capable of producing 60hp at 4,000rpm. This granted the lightweight Willys (1,040kg) a top speed of 45mph and earned the engine the nickname of 'Go Devil' by allied troops. The engine was controlled by a Warner T-84J three-speed synchromesh transmission, which provided three forward gears and one in reverse in a four-wheel drive setup, allowing for the jeep to easily traverse road, desert, scrub and jungle terrain.

The engine was forward-mounted to a lightweight steel chassis. This featured a foldable windscreen, slatted iron grille (later additions a steel grated grille), and front frame cross-member for rigidity and damage mitigation. The chassis sat on top of a compact 80-inch wheelbase that was installed with leaf springs and shock absorbers (excellent for passage over bumpy ground), as well as fully hydraulic brakes on each of its four wheels (granting fantastic stopping power).

The Willys jeep was also prized for its high adaptability, with various different setups possible dependent on mission role. Troop transport maximised passenger space, with extra seats at the rear, while as a mobile medical centre the rear seats could be removed to make way for stretchers, medicines and operating equipment. The jeep could also be installed with various weapons platforms, including a rear-mounted 37mm cannon and array of Browning M1917 machine guns.

upgraded post-war with a larger engine (the F4-134 Hurricane), more durable transmission (Warner T-90) and advanced instrumentation and electronics, it was eventually replaced in the late-Seventies and early-Eighties as larger, more armoured vehicles like the Humvee became the military's primary troop transporters.





The first 25,000 MB Willys ieeps had a flat iron radiator grille. Subsequent jeeps were fitted with a now-famous slotted steel grille, due to its lower weight and cheaper cost.

Competition

The jeep was the product of a competition held by the US Army's Ordnance Technical Committee to design a 1/4-ton 4x4 truck to replace its fleet of bikes and Ford Model Ts.

Popeye

The origins of the term 'jeep' is long-contested. One of the most interesting is that it was so-named by US soldiers after Popeye's jungle pet 'Eugene the Jeep'.

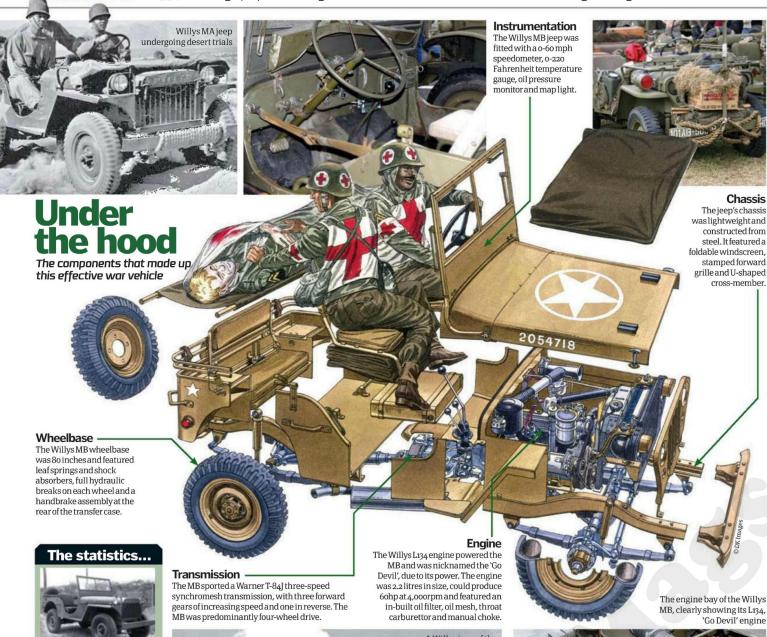
Reproduction

The Willys jeep is considered a collector's vehicle. In 2004 Chrysler - parent company of Willys - reproduced 1,000 Willys Special Edition Jeep Wranglers for sale.

Legacy

5 The compact military jeep continued to be used after WWII with the Willys jeep MB, as well as its successors the M38A1 and M422 used during the Korean and Vietnam wars.

TID YOU KNOW? In 1991, the Willys jeep was designated an International Historic Mechanical Engineering Landmark





Crew: 3

Capacity: 5

Length: 3.3 metres (131 inches) Width: 1.57 metres (62 inches)

Height: 1.83 metres (72 inches)

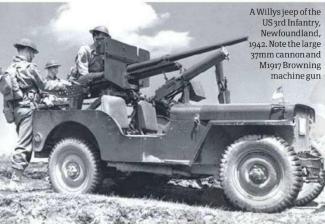
Weight: 1,040 kg (2,293lb)

4-cylinder, 2.2-litre L134 petrol

Max horsepower: 60hp @ 4,000rpm

Max speed: 45mph (72.4kph) Transmission: Warner T-84J 3-speed sychromesh

Produced: 640,000



V-1 flying bomb

Feared by Allied forces during WWII due to their eerie noise and powerful warheads, the V-1 flying bombs accounted for thousands of casualties



The V-1 flying bomb was a German jet-propelled missile that was infamous during World War II due to the

distinctive spluttering noise of its Argus pulsejet engine, as well as its large blast radius. The weapon was designed and tested by the Luftwaffe at Peenemünde, an island off the north coast of Germany.

The bomb was in essence a crude form of cruise missile, with an 850kg (1,874lbs) payload of the explosive Amatol-39 encased in a rocket-propelled fuselage. Post launch - which could be initiated either from elevated ramps on the ground or by release from airborne aircraft - the missile was guided to its target by a gyrocompass and an electronic autopilot.

The missiles had a range of 250km (160 miles) and were able to cruise up to 915m (3.000ft), As such, the majority of V-1s were launched against Britain from northern France and were difficult to intercept with conventional anti-aircraft guns, forcing Allied troops to attempt to eliminate them with fighter aircraft and barrage balloons.

Used throughout 1944 and 1945, over 30,000 V-1 missiles were produced - more would have been made if it were not for the Allied invasion of France - and 10,000 were launched against Britain, leaving hundreds of buildings demolished (civilian and military) and many dead or wounded. Today no working model still exists, however many examples can still be viewed at military museums throughout Europe and America. 🧶

The statistics...

V-1 flying bomb

Lifespan: 1944-45

Cost: 5,090 RM Length: 8.32m (27.3ft)

Width: 5.37m (17.6ft) Height: 1.42m (4.7ft) Weight: 2,150kg (4,740lb)

Warhead: Amatol-39

Engine:

Argus As 109-014 pulsejet

Max range: 250km (160 miles) Max speed: 644km/h (400mph)

Max altitude: 915m (3,000ft)

Guidance:

Gyrocompass autopilot

Inside the V-1

Warhead

The V-1's payload was 850kg (1,874lbs) of Amatol-39, a highly explosive mix of TNT and ammonium nitrate.

'The bomb was in essence a crude form of cruise missile"

Compass

The V-1's navigation during flight was dictated by a gyrocompass installed in its nose

Detonator

The detonator worked exactly the same way as a firing-pin in a bullet and was located here.

Autopilot

The bomb's height and speed were controlled by a simple electronic autopilot located in the tail

Jet engine

The V-1's power came from its Argus pulsejet engine, which delivered a top speed of 644km/h (400mph).



Fuel tanks

Fuel for the V-1's flight was located in tanks positioned in the centre of the missile's fuselage.







The bouncing bomb was created by British engineer Sir Barnes Wallis, in order to

destroy dams in the Ruhr valley, Germany. The Ruhr valley was one of the dominant industrial areas of Germany, with arms, vehicles and raw materials feeding the Nazi war machine. If the dams were breached, the production potential of the area would be significantly reduced.

The bomb's design was simple yet complex. It consisted of a cylindrical drum housing almost 3,000kg (6,614lbs) of high explosives, which would be detonated once at the base of a dam. Hydrostatic pistons caused massive structural instability from the resultant explosion and shock waves. Generating the explosion, however, was the simple part of the problem; the real challenge was getting the bomb into position.

Multiple torpedo nets, large steel-linked sheets that formed underwater barriers, protected the dams of the Ruhr. These would snag any incoming underwater explosives and prevent explosions near the base. Wallis's bomb, however, was designed to skim across the water's surface, jumping the nets until it made contact.

To achieve this, the bomb needed to be dropped at a specific height

and speed, as well as having a preloaded backspin. Wallis's bombs were used on the 16 May 1943 in Operation Chastise, in which 19 bombing aircraft and 113 attack fighters descended on the Ruhr valley. Two major dams were breached, causing massive flooding and loss of life. These successes came at a cost, however, with eight of the bombing aircraft shot down along with 53 of the fighter planes.

Frame

Areinforced wooden frame, onto which the ram and its chain could be suspended. Early frames were square/rectangular in shape, while later models adopted a better-fortified

triangular shape. resembled that of a ram. Countermeasures (not shown) The wooden frame was covered with protective plates and dowsed animal skins, in order to prevent the ram and its operators

Ram

from being hit with

enemy missiles.

Constructed from either a single or a combination of multiple tree trunks depending on size, the ram was insanely heavy and capped with a iron striking head. The head often

Battering rams

How did these machines break down walls?



Pioneered by the ancient Assyrians, battering rams broke the restrictions of hoplite warfare dramatically,

making formerly impregnable city walls vulnerable to attack. Rams worked by suspending a large, iron-capped wooden trunk under a wooden frame, which was often covered by wooden plates and damp animal skins for protection from enemy missiles (arrows were often lit in an attempt to burn the ram's frame). The ram - with an iron cap that was often forged to resemble a ram's head - was then swung by soldiers within the frame backwards and forwards against the stone wall, eventually leading to its resistance being broken.

Battering rams were not only used as a siege weapon used for over 1,500 years until gunpowder superseded it as the primary method of breaching fortifications, but also in industry. Roman

historian Pliny the Elder describes battering rams being used for mining purposes, where tough, hardened rock needed to be broken to make valuable ores accessible. Today, though, battering rams are usually restricted to handheld devices, used by emergency services to breach doors to gain entry to a compromised building complex.





Battle of Britain

Over 70 years ago an epic conflict took place between allied and axis powers. It was one of the defining moments of World War II and changed the nature of armed conflict forever



The Battle of Britain was an exclusively aerial campaign between allied and axis forces which began in the summer of 1940 and culminated in May of

1941. The objective of the German-led aerial assault on Britain was to completely destroy the Royal Air Force (RAF) and render Fighter Command useless, so a planned land invasion of Britain could begin. The Luftwaffe (Germany's air force) was ordered by Hitler to drive the RAF from the skies in 'the shortest possible time', and led by notable First World War veteran fighter pilot Hermann Wilhelm Göring, the then Reich Minister of Aviation, what was to follow was a costly – in terms of human life and financially – battle of attrition.

At the head of Britain's defence was Hugh Dowding, the then Air Chief Marshal of the RAF and Fighter Command, which had been set up in 1936 to oversee and manage Britain's emerging modern air force. Fighter Command led its RAF-based defence of Britain from Bentley Priory, London, communicating with airfields, radar stations, pilots and other communications headquarters over the south east (where the majority of the battle took

place) and other regions of the country. At his disposal was a well-ordered yet numerically inferior air force to that of the Germans, with many pilots lacking valuable experience.

Contrary to Dowding, Göring inherited a Luftwaffe of great numbers and experience, with many of its pilots having gained valuable flight experience in WWI. This allowed Göring and his commanders to launch large raids on Britain – one of the most notable being a 500-strong assault on 15 September 1940 – causing large damage to a wide variety of areas and military buildings as well as, by the end of the war, 43,000 civilian deaths. Despite Göring's leadership, his other commanders held differences of opinion in how the RAF should be toppled – a factor that Dowding also had to deal with among Britain's commanders in how to defend the country.

Despite their experience and numbers, Germany failed to gain air superiority over Britain and by the end of the Battle they had lost 1,152 aircraft and 1,144 crew, compared to Britain's losses of 1,085 aircraft and 446 crew. Retrospectively, this result was caused by a single piece of state-of-the-art technology, as we find out over the page.



Fighter Command

The men who led Britain's resistance



Name: Hugh Dowding Rank: Air Chief Marshal

Description: An experienced officer, Dowding was set to retire shortly before WWII, only to be persuaded to stay on until the situation had stabilised. He is often credited as the mastermind behind Britain's success in the Battle of Britain.



Name: Keith Park Rank: Air Vice Marshal

Description: In tactical command during the Battle of Britain, Park was in-charge of protecting London from attack. Flying a personalised Hurricane, Park held a reputation as a shrewd tactician.



Name: Trafford Leigh-Mallory Rank: Air Officer Commanding

Description: The commander of 11 Group RAF had open disagreements with Park and Dowding over the tactics to counter the German threat. He was credited as creating the 'Big Wing' fighter formation to hunt German bombers.

Luftwaffe

The men who led the German attack

Name: Hermann Wilhelm Göring **Rank:** Reich Minister of Aviation

Description: The last commander of legendary ace fighter pilot 'The Red Baron', Göring was responsible for German Luftwaffe. In his youth he had flown in the First World War and was respected by the Germans as a notable commander.



Name: Hugo Sperrle Rank: General Field Marshal Field Marshal of the Luftwaffe

Description: General Field Marshal of the Luftwaffe, Sperrle advised Hitler that the destruction of Britain's air force was key to winning the war. Air Fleet 3, which he commanded, played a major role in the battle but suffered heavy losses.



Name: Albert Kesselring Rank: General Field Marshal orchestrated combat in Poland,

Description: Kesselring orchestrated combat in Poland, France and at the Battle of Britain. He is credited with the Coventry Blitz of November 1940 and won the respect of allied powers with his military accomplishments.

Head to Head



1. Hawker Hurricane

The real hero, the Hurricane shot down more aircraft than either of its contemporaries and was the workhorse of



Messerschmitt Messerschmitt Bf 109E and Bf 110C were the Luftwaffe's

3. Spitfire of World War Two, the Spitfire was a formidable opponent, packing firepower, flexibility and

unparalleled dynamism.

DIDYOU KNOW? The RAF lost 1,085 planes during the Battle of Britain, while the Luftwaffe lost 1,152



How the battle was won

Thanks to the skilful implementation of the emerging technology of radar, allied forces were better equipped to counter German attacks

The importance of radar in the Battle of Britain was massive, something that its then leader Hugh Dowding knew all too well. Britain was facing larger numbers of enemy aircraft, pilots with more flight experience and frequent bombing runs in the dead of night – the favoured time for German attacks. Radar then was key, allowing enemy airborne movement to be tracked from across the Channel and, crucially, allowing Britain's smaller air force to be managed more acutely.

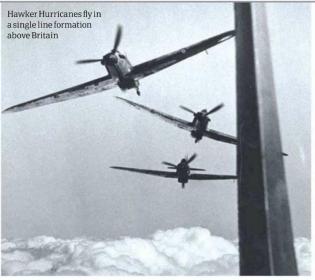
The main advantage that radar gave was the ability to launch intercepting attack aircraft at the right time. Not too early forcing planes to reland for refuelling, leaving them vulnerable to attack and costing cash-strapped Britain in fuel bills and equally not too late - giving the German planes a crucial height advantage in the proceeding dogfight and allowing them to reach inland areas of Britain. Dowding, operating his stringent Fabian Strategy, used this to great effect, having information on approaching aircraft sent from coastal stations to Bentley Priory (Fighter Command headquarters) with great haste so that finessed tactical plans could be quickly drawn up and relayed to air force bases.

The system did have drawbacks however. While radar was excellent and highly accurate in detecting aircraft movement, it was quite poor in expressing the numbers of aircraft and their formations, two factors crucial in decision-making if an effective

resistance was to be mounted. Because of this, Dowding's system also incorporated RDF-based detection - which allowed formations to be determined as they formed over France - and the pre-existing Observer Corps, groups of mainly volunteer civilians dotted throughout Britain, visually relaying information on approaching aircraft numbers and formations to Fighter Command. Indeed, many historians argue that without the Observer Corps, no matter how refined Britain's radar-based systems became, the Battle of Britain would've been lost - an opinion vocalised by Dowding when he said that "they constituted the whole means of tracking enemy raids once they had crossed the coastline. Their works throughout [the war] was quite invaluable."

Importantly, despite the benefits radar was providing Britain's air force, Göring and his commanders underestimated its ability and importance in what was going to be the deciding factor in the Battle of Britain. While initially the Luftwaffe were ordered to attack RAF radar stations (an activity they completed with little success, knocking out only one radar station on the Isle of Wight for under 24 hours), their attention was soon turned to the towns and cities of Britain, as their grip on the conflict slackened. It is generally agreed by historians that if Göring had persisted with his targeting of Britain's radar stations, Germany would have had considerably more success than they historically achieved.

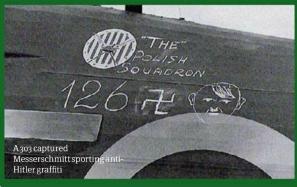






303 Squadron

The Battle of Britain saw over a thousand enemy aircraft shot down by British RAF squadrons, and none more so than the famous Polish 303s. No. 303 Polish Fighter Squadron was one of 16 Polish squadrons in the Royal Air Force during the Second World War and won acclaim for their marksmanship and aerial ability during the conflict. Scoring higher than any other squadron, 303 competed with other RAF squadrons in a competition as to who could shoot down the most enemy aircraft. By the end of the Battle of Britain they had won unequivocally, recording an immense 808 hits. In fact, the top three places in this competition's leaderboard were taken by three of the 12 Polish squadrons, outgunning the best British squadron by far, who only racked up 150 hits.





Baron

Reich Minister of Aviation Hermann Göring was the last commander of the legendary World War I fighter ace Manfred von Richthofen, aka 'The Red Baron'.

Speech

The naming of the Battle of Britain originated from a speech by Winston Churchill, when he said: "The Battle of France is over. I expect the Battle of Britain is about to begin."

xis

Joining the Luftwaffe in the attack on Britain during the battle was a small section of the Italian Air Corps, which saw much action in late 1940 but with limited success.

Eagle

The first main attack on Britain by Germany was code-named 'Eagle Attack', and it was designed to knock out numerous allied radar stations.

Celebration

The Battle of Britain is commemorated each year in the United Kingdom on 15 September, where it is referred to as Battle of Britain Day.

DIDYOU KNOW? No. 303 Polish Fighter Squadron recorded 808 hits during the Battle of Britain







Interview

We speak to RAF historian **David Keen** about the ins and outs of the Battle of Britain



Was the Battle of Britain a turning point in World War II?

The Battle of Britain was not a turning point in the war but was highly influential in the direction that it progressed. This was because in winning the Battle of Britain, Hugh Dowding, the then Air Chief Marshal of the RAF, prevented Fighter Command from being destroyed by the Germans and the Luftwaffe gaining complete air dominance. If this had been the case then Hitler could have rolled out his planned sea and land invasion of Britain (Operation Sea Lion) with very little resistance and the American forces would have had no base to launch their own attacks from.

In what state was Britain's air force in the run-up to the battle, how were the odds stacked?

The German Luftwaffe found themselves in a strong position going into the Battle of Britain, with a solid infrastructure in place from World War I, vastly experienced pilots who had seen much combat experience during the Spanish Civil War and a total numerical superiority. The British, in contrast, had been very slow to start in its preparations for war and modernisation of their outdated air force. For example, Fighter Command was only set up in 1936 and without Dowding's good management and re-organisation would have struggled to combat the German threat. The RAF was also numerically inferior going into the battle and had less experienced pilots.

How important was Dowding and his integration of radar in the allied victory?

The integrated use of radar was very important as it gave Fighter Command a far greater view over the Channel than it had ever had before, allowing approaching aircraft to be detected and identified far sooner and that information relayed back to Bentley Priory, Fighter Command's headquarters. By splitting the RAF into four main sectors – 10 for the south east, 11 for London, 12 for the Midlands and 13 for the north

and Scotland, the radar garnered information could then be filtered quickly and effectively to the area of the country were action was necessary.

Aircraft had taken a big step forward since they were last used in the First World War, what technology did the RAF and Luftwaffe have?

The RAF used two main fighters during the battle, the Hawker Hurricane and the Spitfire. Despite the Spitfire's lasting fame as the poster vehicle of the war, it was the Hurricane that was in greater use by the RAF and they shot down more enemy aircraft than the Spitfire throughout. The Hurricane was a solid fighter and was seen as the workhorse of the allied forces. providing good all-round performance and a solid gun platform. The Spitfire, for which there were fewer numbers, was the superior vehicle and in the hands of a fighter ace was a more formidable opponent though. In contrast, the Luftwaffe used mainly the Messerschmitt 109, which was classed as a heavy fighter and was famed for its stability. Despite the aircrafts' differences, they were largely the same and a skilled pilot in one would normally always get the better of another with an amateur at the helm.

Finally, in retrospect, what should Germany have done to win the Battle of Britain?

Indecision and the spreading of forces was the real downfall for Germany at the time, something that stemmed right from the very top of the chain of command. Before their invasion of Poland, Hitler had promised Britain that if they left Germany alone during its military campaigns then he would leave it alone in payback, something that was favoured by many in Britain at the time. So when Germany found itself at war with Britain, no firm invasion plan had been secured and after Göring and his commanders failed to deliver the quick victory they predicted, many conflicting tactics entered the fray. With no land and sea invasion in place, the Luftwaffe were constantly ordered to change their bombing priorities, sometimes to go after Britain's radar stations, sometimes their cities. Further, as Germany's progress on the Eastern front stagnated against the Russians, more and more aircraft were diverted to bolster their forces. In order to win the Battle of Britain Germany should have concentrated on Britain's radar stations, then once they were destroyed shifted their total focus onto the airfields.

RAF museum

The RAF museum in London is packed with information and aircraft, and it is worth visiting its recently refurbished Battle of Britain exhibition hall. For more information about the Battle of Britain and what's on at the museum visit:

www.rafmuseum.org.uk.





Supermarine Spitfire

Arguably the most iconic fighter aircraft of the Second World War, the RAF Spitfire to this day is championed for its prowess, grace and versatility

Rolls-Royce -Vee-12 engine

The Spitfire utilised two variant of Rolls-Royce engine during its production life span, the 27-litre Merlin and the 36.7-litre Griffon.

Propeller

Original Spitfires had wooden propellers, these were later replaced with variable-pitch propellers, and more blades were added as horsepower increased.

Airframe

The aircraft's airframe was an amalgamation of a streamlined semisingle piece of aluminium alloy with an enclosed cockpit, allowing increased responsiveness and ease of flight.



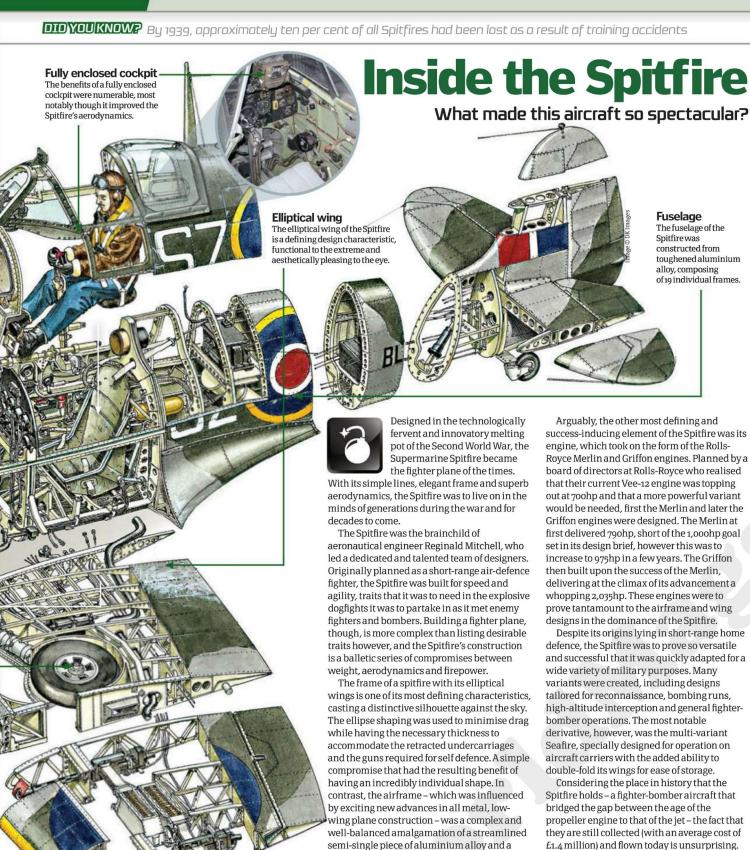
Undercarriage

The Spitfire's undercarriage was fully retractable, a refinement that was not commonplace in earlier aircraft.

Gun-emplacement The original armament of

the Spitfire comprised of eight 303-inch Browning machine guns, each with 300 rounds of ammunition.

MAX SPEED 450mph RANGE 400 miles LENGTH 32ft 11ins WINGSPAN 36ft 11in ARMAMENT 20mm cannon x4



fully enclosed cockpit. This allowed unrivalled

responsiveness and ease of flight, making the

Spitfire a favourite for pilots.

Arguably, the other most defining and success-inducing element of the Spitfire was its engine, which took on the form of the Rolls-Royce Merlin and Griffon engines. Planned by a board of directors at Rolls-Royce who realised that their current Vee-12 engine was topping out at 700hp and that a more powerful variant would be needed, first the Merlin and later the Griffon engines were designed. The Merlin at first delivered 790hp, short of the 1,000hp goal set in its design brief, however this was to increase to 975hp in a few years. The Griffon then built upon the success of the Merlin, delivering at the climax of its advancement a whopping 2,035hp. These engines were to prove tantamount to the airframe and wing

defence, the Spitfire was to prove so versatile and successful that it was quickly adapted for a wide variety of military purposes. Many variants were created, including designs tailored for reconnaissance, bombing runs, high-altitude interception and general fighterbomber operations. The most notable derivative, however, was the multi-variant Seafire, specially designed for operation on aircraft carriers with the added ability to double-fold its wings for ease of storage.

Considering the place in history that the Spitfire holds - a fighter-bomber aircraft that bridged the gap between the age of the propeller engine to that of the jet - the fact that they are still collected (with an average cost of £1.4 million) and flown today is unsurprising. The Spitfire is a timeless piece of engineering that shows some of the most creative and advanced efforts in military history.



Lancaster bomber

Famed for its prowess and entrenched in popular culture by The Dam Busters film of 1955, the Lancaster bomber played a vital role in securing an allied victory in World War II



Arguably the most famous heavy bomber of World War II, the Avro-built Lancaster bomber undertook some of the most

dangerous and complex missions yet encountered by the RAF. Primarily a night bomber but frequently used during the day too, the Lancasters under Bomber Command flew some 156,000 sorties during the war, dropping 609,000 tons of bombs. Among these bombs was the famous 'bouncing bomb' designed by British inventor Barnes Wallis, a payload that would lead the Lancaster to remain famed long after 1945. On these pages you can take a look inside a Avro Lancaster to see what made it so successful.



dropped 609,000 ton

Due to its large size, hefty armament and technical complexity, the Lancaster bomber had a crew of seven. This included: a pilot, flight engineer, navigator, bomb aimer, wireless operator, mid-upper and rear gunners. Many crew members from Lancasters were awarded the Victoria Cross for their heroic actions in battle, a notable example being the two awarded after a daring daytime raid on Augsburg, Germany.

Inside a Lancaster bomber

Bomb bay

The bomb bay could carry a great payload. Indeed, the bay was so spacious that with a little modification it could house the massive Grand Slam "earthquake" bomb, a 10,000kg giant that when released would reach near sonic

Fuselage -

The Lancaster was designed out of the earlier Avro Type 683
Manchester III bomber, which sported a three-finned tail layout and
was similar in construction. While the overall build remained similar
the tri-fin was removed in favour of a twin-finned set up instead. This is
famously one of only a small number of design alterations made to the
bomber, which was deemed to be just right after its test flights.

Turrets

As standard the Lancaster bomber was fitted with three twin 7.7mm turrets in the nose, rear and upper-middle fuselage. In some later variants of the Lancaster the twin 7.7mm machine guns were replaced with 12.7mm models, which delivered more power. The rear and upper-middle turrets were staffed permanently by dedicated gunners, while the nose turret was staffed periodically by the bomb aimer when caught up in a dogfight.



High calibre

While 7.7mm machine guns
were standard on Lancaster
bombers, selective later
variants were fitted with twin
12.7mm turrets in both tail and
dorsal positions.

Slam-dunk

Lancaster bombers often had their already-large bomb bays modified in order to carry the monumental 10,000 kilogram Grand Slam "earthquake" bombs.

Busted

A selection of bombers became famous after Operation Chastise, a mission to destroy German dams in the Ruhr Valley, the inspiration for the film *The Dam Busters*.

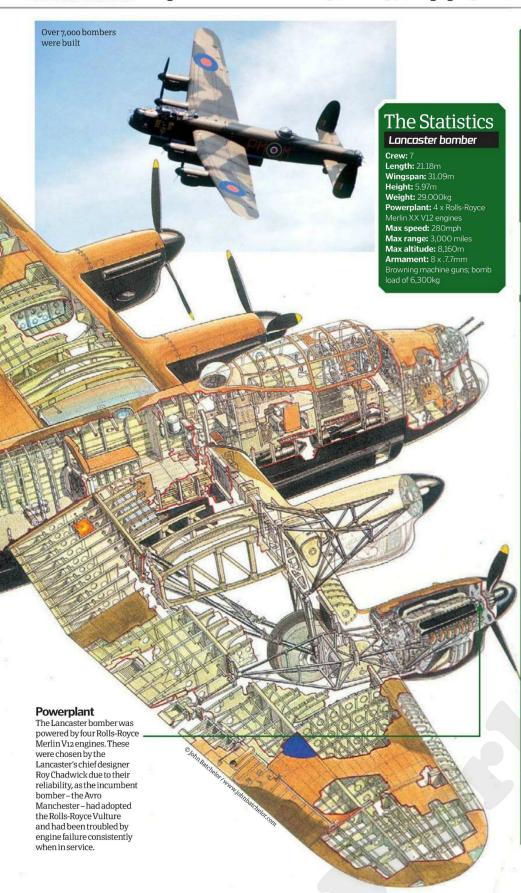
Collateral

4 Between 1942 and 1945 Lancaster bombers flew 156,000 sorties and dropped approximately 609,000 tons of bombs on military and civilian targets.

Black label

The lager company Carling used footage of Lancaster bombers to create a parody of The Dam Busters in which a German soldier catches the bouncing bombs.

DIDYOUKNOW? A single Lancaster bomber cost £50,000 in 1942, roughly £1.5 million in today's currency

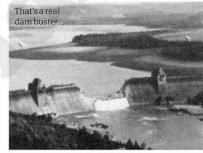


The bouncing bomb

One of the most famous parts of the Lancaster's heritage is its role in carrying and releasing the 'bouncing bomb' payload, as glamourised in the 1955 film *The Dam Busters*. The bomb was designed by Barnes Wallis – who was also the creator of the Grand Slam and Tallboy bombs – and was special in its ability to bounce along the top of a surface of water, much akin to skimming a stone. It was designed to counteract and evade German defences below and above the waterline, allowing Allied forces to target German hydroelectric dams and floating vessels.

In May 1943 the bouncing bombs were utilised in Operation Chastise, an allied mission to destroy German dams in the Ruhr Valley. The aircraft used were modified Avro Lancaster Mk IIIs, which had much of their armour and central turret removed in order to accommodate the payload. Despite eight of the Lancasters being lost during the operation, as well as the lives of 53 crew, a small number of bouncing bombs were released and they caused two dams to be breached, one to be heavily damaged and 1,296 civilians to be killed.





Messerschmitt Me 262

How this German fighter aircraft brought terrifying speed and combative dominance to the aerial battlefields of World War II



Airframe

The Me 262's airframe was made from steel and aluminium alloy, while the cockpit canopy consisted of two rounded plastic glass sections mounted in a frame on a tubular base. The airframe was fitted with a tricycle undercarriage arrangement.



Armament

Weaponry included four somm (1.2in) MK 108 cannons, 24 55mm (2.1in), unguided R4M rockets and either two 250kg or 500kg (550lb or 1,100lb) free-fall bombs.



Speed kills. This is a fact of war that the Nazi regime understood well, employing it to great effect with their 'Blitzkrieg' (lightning war) tactics of WWII,

puncturing holes in Allied lines with great speed and firepower. It was a mantra they incorporated into all aspects of their military and, as shown in the groundbreaking Messerschmitt Me 262 fighter jet, often generated spectacular results.

The Me 262 was the most advanced aviation design brought to fruition during World War II, and the first ever operational jet-powered fighter aircraft in the world. It featured a state-of-the-art, streamlined steel and aluminium alloy chassis, twin super-powerful Junkers Jumo 004 B-1 turbojet engines and a suite of weaponry that allowed it to fulfil a wide variety of roles. It was originally conceived to be a high-speed fighter-interceptor used to take down Allied bombers during sorties (flight missions), however under order from Adolf Hitler himself, its role was widened to also include bombing duties.

"The Me 262 was the most advanced aviation design brought to fruition during World War II"

Its aerial dominance rested on its high top speed of 900km/h (560 mph), which obliterated its nearest rivals, the American P-51 Mustang and British Spitfire. Indeed, the velocity that the Me 262 brought to the aerial battlefield meant that traditional dog-fighting tactics needed to be rewritten, with Allied pilots unable to track the aircraft with their electric gun turrets or tail them over long stretches. Instead, Allied pilots had to gang up and attempt to force the 262's pilot into making low-speed manoeuvres, from which it could be shot down.

This formidable power came from the turbojets. They didn't provide as much thrust at lower speeds than that of propellers, meaning that Me 262s took longer to reach high speed. However, once flying, the aircraft could easily outpace any Allied plane. Further, the turbojets granted the Me 262 a higher

rate of climb than its contemporaries, which – when used tactically – allowed them to out-position the enemy aircraft and line up attack runs on lower-flying bombers.

Air-to-air damage was delivered with four 30mm MK 108 cannons, as well as 24,55mm R4M rockets. The Me 262's cannons allowed for short-range firing runs, while the unguided R4M rockets allowed larger targets to be peppered with high-explosive munitions, each one capable of totally destroying any aircraft of the day. Air-to-ground attacks were actualised through a selection of 250kg or 500kg (550lb to 1,100lb) free-fall bombs, which were stored and released from dedicated bomb bays. Through its weaponry and intense speed, the Me 262 racked up a reported five-to-one kill rate, shooting down a variety of different Allied aircraft.

5 TOP FACTS THE ME 262

Delay

dedicated large quantities of bombing sorties to

launch bases.

destroying any known construction factories and

The Me 262 was not introduced until the spring of 1944.
Massive delays in attaining operational status for its Junkers Jumo 004 B-1 turbojet engines held it back.

00°

Post war, former Me 262 pilot Hans Guido Mutke claimed to be the first to ever exceed Mach 1, alleging that on 9 April 1945, he broke the limit in a straight-down 90° dive.

Survivors

Wery few original Me 262s still exist today, with limited production run during the war and heavy dismantling after it, leaving less than 11 of the aircraft in existence.

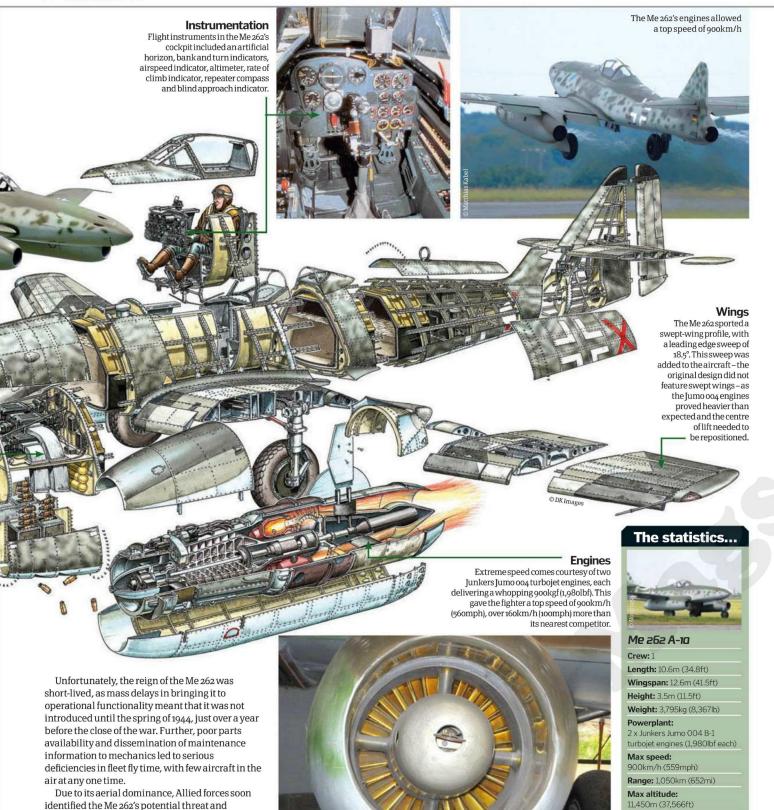
Dominance

4 Allied pilots struggled to counter the Me 262's dominance, so decided to undertake bombing runs during 1944 and 1945 on Me 262 production factories.

Fly-along

The Collings Foundation's recent reconstruction project built three Me 262s, their Jumo 004 engines replaced with J-85s. They're now being booked for fly-along sessions.

DIDYOUKNOW? The Messerschmitt Me 262 was the first operational, jet-powered fighter aircraft in the world



Armament: 4 x 30mm MK 108 cannons, 24 x 55mm R4M

rockets, 2 x 250kg bombs



The B-17 Flying FOREB-17 Flying Controls and instruments The bombardier perches inside the nose to operate the Norden bombsight and Controls and instruments The instrument panel and controls feature 190 handles, gauges, dials, switches and cranks that

The B-17 was designed in 1934 by Boeing to take part in a US Army Air Corps competition to produce a modern multi-engined bomber. Their Model 299 prototype first flew on 28 July 1935, and a journalist nicknamed it the 'Flying Fortress'.

In October 1935, the prototype crashed and the design lost out to the Douglas DB-1. Fortunately, the Air Corps recognised it was a promising aircraft and ordered 13 299s in January 1936, which they designated the Y1B-17. Not long after, the Y1B-17 became the B-17, and Wright Cyclone engines replaced the 299's Pratt & Whitney Hornet engines.

In 1938, another big advance was the introduction of turbo super-chargers to the engines of a B-17A test aircraft that could take it to an altitude of 9,144 metres (30,000 feet). The B-17B became the first production model, but at the outbreak of World War II, only 30 of them were operational. In 1940, 38 B-17Cs were built with better-armoured protection, and only 42 B-17Ds were rolled out before mass production of the redesigned B-17E, B-17F and the ultimate B-17G models. Out of the total production run of 12,725 B-17s, 512 were E-class, 3,400 were F-class and 8,680 were G-class.

To fulfil its promise as a precision strategic bomber, it was fitted with the top-secret Norden bombsight. This was a gyroscope-stabilised device that calculated the dropping angle and drift of the aircraft to enable accurate high-altitude bombing.

The B-17 gained a reputation for being able to sustain high levels of damage and capable of being brought back to land by relatively inexperienced crew members when necessary.

It is believed around 5,000 B-17s were shot down or destroyed in their mission to eliminate industrial and military targets during WWII.





During attacks B-17s tended to fly in a wedge formation for greater protection

B-17 updates

The B-17 went through a range of modifications and design changes in line with experience and mission requirements. Its range could be extended with the use of bomb bay and 'Tokyo' fuel tanks, and it could carry additional bombs on special external racks. Defensive weaponry on the craft was revised and changed on various models, with the introduction of powered turrets and additional gun slots. The weight of the ammunition meant that each gunner got about 500 rounds that would give one minute of constant fire. Despite being a 'flying fortress' it did need nippier fighter aircraft escorts to give it the best protection during daylight raids.

Head to Head WORLD WAR II BOMBERS



1. Boeing B-29 Superfortress Coming late to the war, the B-29 had more weapons, plus could fly higher and faster than the B-17. It was never deployed in Europe.



2. Consolidated B-24 Liberator The B-24 could carry a

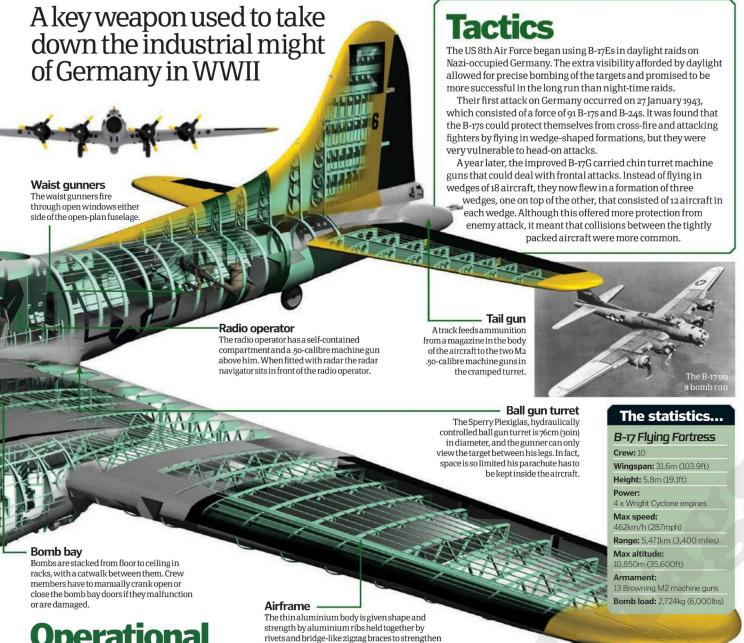
The B-24 could carry a larger bomb load further and faster than the B-17, but it was harder to manoeuvre and keep in close formation.



3. De Havilland Mosquito

The Mosquito beat the B-17 in terms of speed – 563km/h (350mph) – and range but could only carry a 1,814kg (4.000lb) bomb load.

DIDYOUKNOW? After WWII, the CIA used B-17s to parachute spies into China, Tibet and a Soviet Union Arctic research base



Operational history

The B-17 was originally conceived as a coastal defence weapon or strategic day bomber, so when the RAF was supplied with 20 B-17Cs in 1941 they were unimpressed by its inability to bomb accurately above 6,096 metres (20,000 feet) – these were not fitted with the Norden bombsight – and its lack of armoured protection. 90 Squadron used the aircraft in the Middle East and for reconnaissance missions by Coastal Command.

The vast majority of B-17s were used by the US 8th Air Force to fight the war in Europe. Some B-17s were deployed in the Far East and South Pacific where they were involved in bombing Japanese convoys and troop concentrations in Java and the Philippines. In the Mediterranean and North Africa, B-17s attacked naval targets and took part in night-time reconnaissance missions.

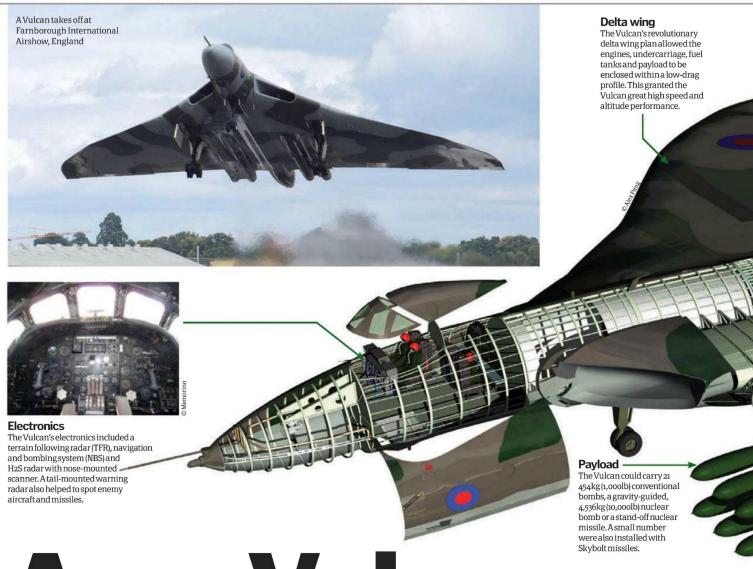
the wings inside.

After the war, B-17s were modified by civilian airlines to carry passengers or cargo, or to fight forest fires or carry out photographic surveys. The Israeli Air Force used a small number in the 1948 War of Independence and the US Army Air Force used them for testing equipment, target drones and weather reconnaissance.

Some of the crew of B-17E 'Typhoon McGoon II', taken in New Caledonia in the West Pacific Ocean, in 1943







Avro Vulcan

The world's first delta-winged bomber, the Avro Vulcan was an aerial titan, capable of delivering a 4,536kg nuclear bomb to any hostile target within a huge radius



Born in the aftermath of WWII – where despite years of conventional warfare, the war was won in the east with the dropping of two atomic bombs – the Avro

Vulcan was designed to be Britain's first line of atomic offence in future conflicts. A new era of modern warfare was emerging from the flames and dust that had consumed Europe, Africa, Russia, Japan and others. No longer would wars be fought and won by armies – they were to be prevented through the power of splitting the atom.

The Vulcan was conceptualised as a highaltitude, high-speed, strategic bomber, capable of delivering a single 4,536kg (10,000lb) nuclear weapon to any target within a distance of 2,776km (1,725 mi). To achieve this demanding brief, the aircraft needed to feature an innovative aerodynamic structure, as conventional aircraft of the day were unsuitable. Further, as the nuclear weapon itself had yet to be invented, the aircraft would have to be developed in partnership with it, adjusting its plans accordingly.

Upon completion of the Vulcan prototype, it featured a revolutionary delta wing planform – a triangular wing layout – that granted phenomenal lift and airframe manoeuvrability. The planform also allowed the jet to fly at high subsonic and transonic speeds with ease and granted it a high angle of attack and stall angle. These features also meant it was stable when cruising at low speeds – something normal wings on high-speed aircraft were unable to do safely. In addition, its sleek aerodynamic profile – despite its large size – gave

5 TOP FACTS AVRO VULCAN

Blue

The Avro Vulcan was developed with the Blue Danube, Britain's first operational nuclear bomb. This led to the Vulcan being designed with a shortened fuselage to accommodate it.

ive

2 The Vulcan required two pilots, two navigators and an air electronics operator (AEO). Despite the large crew, only the pilots were provided with ejection seats.

our

Upon completion of the first Vulcan, the RAF sent it on a world tour. Unfortunately, on 1 October of the same year, upon attempting to land back at Heathrow, it crashed.

Combat

4 The only fully fledged combat missions involving the Vulcan took place during the Falklands War. A trio attacked Argentinean airfields and radar installations.

Anonymous

There is only one Vulcan still operational. In February 2010, it was to be decommissioned due to lack of funding. Luckily, though, an anonymous benefactor granted £458,000.

DID YOU KNOW? A total of 134 production Vulcans were assembled at Woodford Aerodrome



the Vulcan a small radar cross-section, providing a decent level of stealth.

Four colossal Bristol Olympus axial-flow turbojet engines, each capable of delivering 4,990kg (11,000lb) of thrust, powered the Vulcan. The engines were paired and buried in the delta wings close to the fuselage, and were fed with air through two large letterbox-style inlets in the wing root leading edge. The positioning of the engines and short fuselage allowed a larger space to be reserved for internal equipment and payload. At full power, the Vulcan could hit a top speed of 1,122km/h (697mph), just shy of Mach 1, and could cruise at 912km/h (967mph/Mach 0.86).

Partnering the Vulcan's revolutionary design was a comprehensive suite of avionics and electronic

systems. Navigation and bombing was handled by an H2S radar with nose-mounted scanner, the first ever airborne, ground-scanning radar system. This allowed the Vulcan's crew to identify and engage targets in night or poor-weather conditions. In addition, a Red Steer tail-warning radar allowed the jet's Air Electronics Operator to quickly spot enemy fighter aircraft and launch chaff and flares accordingly to negate missile attacks. In the second edition of the aircraft, the Vulcan was also outfitted with an AC electrical system, flight refuelling probe, autopilot system and electronic counter measure (ECM) suite.

Both the Vulcan's design and advanced technology worked together in order to aid its ability to deliver munitions to enemy targets. Across its life span, the Vulcan was armed with a variety of nuclear and conventional weapons, ranging from standard free-fall bombs, through nuclear bombs and onto standoff nuclear missiles. Luckily, despite its huge arsenal, the Vulcan was never actually called upon to go nuclear – if it had been, who knows what shape the world would be in today. Instead it only saw one combat operation (Operation Black Buck) in the Falklands War, dropping conventional bombs on Port Stanley Airport, Falkland Islands.

Despite lack of actual combat missions, the Avro Vulcan is nevertheless seen as a remarkable engineering achievement in its own right. It is considered by military historians to be a piece of technology central to nuclear deterrence throughout the 20th Century.



Dassault Mirage Alightweight aircraft hoasting diverse multi-role

A lightweight aircraft boasting diverse multi-role functionality, the Mirage 2000 epitomises fourth-generation fighter jets



Navigation

A Thomson-CSF RDM multimode radar allows the 2000C to easily migrate between air-to-air and air-to-surface operations, engaging multiple targets at any one moment.

Avionics

The 2000C is equipped with a ULISS 52 inertial navigation system, TRT radio altimeter, Type 2084 digital flight controller and Sextant Avionique Type 90 air data computer.



Despite being overshadowed by more glamorous aircraft over the last 30 years, the Dassault Mirage 2000 series of multi-role fighter jets has quietly

delivered excellent functionality and cost efficiency for its operators, which as of 2012, includes nations from Europe, through the Middle East and on to Asia. Of course, it is not all über-hyped ecocredentials and safety features that have heightened and maintained the Mirage's popularity among air forces worldwide – but primarily its ability to deliver extreme lethality to air, sea and land targets alike with a whole arsenal of deadly weapons.

We're talking nine hardpoints, two powerful revolving 30-millimetre (1.2-inch) cannons, multiple Matra rocket pods each capable of launching 18 68-millimetre (2.7-inch) unguided rockets, two R550 Magic short-range air-to-air missiles, two Super 530 medium-range air-to-air missiles, two Exocet AM-39 anti-ship missiles, two AS-30L, laser-guided

AMirage 2000B variant pre-takeoff. The jet can climb 16,154m (53,000ft) in 60 seconds

air-to-ground missiles and the motherload... the ability to deliver a single ASMP tactical nuclear cruise missile into the heart of any region within a 300-kilometre (186-mile) range. As mentioned, when you have this vastness and flexibility of payload on offer, maintenance becomes less of an issue, as let a 2000-series out of the hangar and soon there are no targets left to hit.

Complementing this insane level of firepower are equally mind-boggling performance characteristics, something granted by the collaboration of a slick delta-wing planform and explosive SNECMA M53-P2 afterburning turbofan powerplant. The M53-P2 enables the Mirage 2000 to hit a top speed of 2,400 kilometres (1,500 miles) per hour and allows it to climb to an altitude of 16,154 metres (53,000 feet) in a minute. The engine's power – which produces on afterburner a maximum of 98 kilonewtons (22,000 pounds force) of thrust – is enhanced thanks to the 2000's adjustable half-cone air intakes, which provide inclined shocks of air pressure for an incredibly efficient air intake at high speeds.

And it is at these high speeds that the Mirage 2000's delta-wing planform comes into its own,

Nuclear

The Mirage 2000 can carry and launch an ASMP nuclear cruise missile. This is a supersonic stand-off missile powered by a liquid-fuel ramjet. It has a max range of 300km (186mi).

Varied

The Mirage 2000 is currently operated in many countries worldwide, ranging from its origin country, France, to nations the other side of the planet like Brazil and India.

Marcel

The Mirage's manufacturer, Dassault Aviation, was founded by Marcel Dassault in 1930. The company is now the foremost aerial defence contractor in France.

Zippy

The design phase of the Mirage 2000 project was incredibly swift, with the jet going from concept, through prototyping to production in just seven years (1975-1982).

Despite being introduced almost 30 years ago, the Mirage 2000 is still in active service. Most recently, French Mirage 2000s helped enforce the Libyan no-fly zone in 2011.

DIDYOU KNOW? Dassault Mirage 2000s featured prominently in the 2005 film Sky Fighters



delivering an almost snake-like agility and fluidity of movement that was difficult to match. This works because the triangular rearward sweep angle of the jet's wings vastly lowers the airspeed normal to their leading edges, while ensuring the over-wing speed remains less than the speed of sound. This, when combined with their inherent large surface area, grants huge lift and minimal wing per unit loading and, as such, super-high airframe manoeuvrability.

This agility is further enhanced by the Mirage being designed with an offset neutral point, which is pushed further forward than its centre of gravity. This makes the aircraft fundamentally unstable during flight, which enables the pilot to make tighter, physics-bending moves that aren't possible in other jets.

Indeed, the double-whammy of awesome performance and potential to deal massive damage when cleared for takeoff is ensuring that, despite the Mirage production programme ceasing back in

Despite the Mirage 2000 production programme ending in 2007, many are still in active service today

2007, the jet is still being actively used today, representing countries at both home and abroad. A good example of this continued respect for the aircraft's abilities can be seen in France's recent deployment of Mirage 2000s in the enforcement of the no-fly zone in Libya back in 2011.

Length: 14m (47ft) Wingspan: 9m (29ft) Height: 5m (17ft) Powerplant: 1 x SNECMA M53-P2 turbofan (64kN/14 388lbf) Max speed: Mach 2.2

Crew: 1

Dassault Mirage 2000C

(2,400km/h; 1,500mph)

Max range: 1,550km (963mi) Max altitude: 17,060m

(59.000ft)

Armament: 2 x 30mm cannons, 2 x 68mm Matra rocket pods, 2 x Matra R550 Magic-IIs, 2 x AM-39 Exocets, 2 x AS-30L laser-quided missiles, 1 x ASMP tactical nuclear cruise missile, 9 x Mk 82 free-fall bombs

30mm (1.2in)





How ancient chariots worked

In the Ancient Near East, the chariot core was dominated by the elite warriors of the age. Here, the chariot was as revolutionary to the military as the modern fighter plane



Atop a chariot, the warrior was a very dangerous foe



The word chariot comes from the Latin 'carrus', which means wheeled vehicle. It had various uses, but in the Near East the chariot dominated the battlefield. These vehicles first

appeared in Mesopotamia around 3,000-2,500 BCE. At first they were heavy and cumbersome, but as time passed they were designed with agility in mind, being made of light timber, plant fibres and leather. Design improvements were most noticeable during the Egyptian New Kingdom period, when the spoked wheel offered better control and turning.

The chariots of the Egyptians and Assyrians were designed to engage the enemy on wide, flat plains. They had semi-circular barriers that protected the driver while he controlled the vehicle, and were drawn by two horses attached to a central pole. The basket, which rested on a beam connected to the wheels, carried the driver, a shield bearer and a warrior, and was equipped with archery



equipment, swords and auxiliary weapons. From this elevated position, the bow became the soldier's principal weapon. From this platform, the warrior could easily decapitate enemy soldiers with his sword. The Egyptians included many magnificent chariots in their burials. While simple military vehicles were made of wood and leather, others were cast in gold.

The rocky terrain of Greece meant that the chariot was ineffective in battle. Therefore, the ancient Greeks employed the chariot mainly as a ceremonial vehicle. Chariots were also used in racing tournaments, and in Rome they were drawn by magnificent horses that could be placed two to five abreast. The Circus Maximus was an arena that held chariot races; this enormous track was so wide, it could support 12 competing chariots. Essentially, the chariot played a significant role in the development of these ancient empires in a number of social spheres.

How Samurai made swords

What makes samurai swords so tough?



Samurai don't just see their swords as beautifully crafted weapons, they actually believe the sword embodies their soul. And so the process of creating such a treasured piece of kit is a measured and intricate one. The swords are made using a high-quality steel known as tamahagane, which is repeatedly heated, hammered flat and then folded.

There are several reasons behind this repetitive action. One is to eliminate any blade-weakening air bubbles that get into the steel during the heating process. Also, the process creates layers in the metal, which adds to the blade's strength. Not only this, but it also ensures that the natural strengthening property in the carbon is distributed evenly throughout the blade.

The blade cannot be thrust into cold water to harden as cooling it too quickly would make it brittle upon contact with a combatant. Conversely, cooling it too slowly would make it soft and blunt. So samurai swordsmiths developed a method of optimum cooling for maximum strength. A thin layer of clay (made of ash, water and clay) was applied to the cutting edge of the sword keeping it hard and sharp, while a thicker layer was painted onto the back of the sword making it supple and shatterproof. With two edges cooling at different rates, the sword gets a distinctive curvature. A piece of art and a deadly weapon.

The longbow

Get to grips with this essential English weapon



Although first depicted in Stone Age cave drawings, the English longbow slowly and surely became the dominant weapon of medieval warfare. Typically about 6.6-feet long and made from yew, longbows developed from the earlier short

bows and warbows and by the time of the 100 Years War they were more than proving their merit. Capable of shooting up to seven arrows a minute and from a distance of nearly 250 yards, longbows provided the crucial advantage at the battles of Crecy (1346) and Agincourt (1415).

As the century progressed, however, their limitations were exposed by the need to penetrate ever stronger armour. As battlefield tactics developed they were first outmanoeuvred and then rendered obsolete by muskets and other gunpowder-based weapons.



Military flails

The crushing power of these weapons of war explained



Flails originated as agricultural tools to thresh crops, a process of beating

grain to separate them from their husks. During the Middle Ages, however, the tool was converted into a weapon, often used by peasant armies.

The military flail itself is a simple device with a striking implement - usually a spiked ball - attached via a chain to a gripping shaft. The weapon was operated by its user striking the enemy's shield with the gripping shaft's tip, causing the chain to whip the striking implement over it to deal a piercing blow. This technique allowed largely unskilled peasants to engage armoured enemies from a distance. Conversely, however, the flail lacked precision and effectiveness in close combat.

The damage-dealing

This was designed to inflict as much physical

impact as possible,

swinging over the

enemy's shield.

part of the military flail

was a spiked, metal star.

Grip

Usually bound leather, a wrist chain was often attached to ensure the weapon was not pulled from the attacker's hand post-strike.

Shaft

The main shaft varied in length, depending on the user's ability and combat role. Larger shafts gave greater reach, yet slowed striking time.

Tip

The tip of the flail was often reinforced, as this was the part that connected with the enemy's shield. Metal and leather caps helped absorb the pre-strike contact and decrease the chance of the woodsplitting.

Chain

Military flails of rope or leather were soon replaced with metal chains for durability

The pirate cutlass

A blade that's a cut above the rest...



Guard Cupped guards,

which protected

the hand during

often decorated

themed designs

combat, were

with pirate-

The cutlass was favoured by navies as it was tough enough to cut canvas, ropes and wood, yet small enough for combat on board a cramped ship. Today we mainly associate them with the pirates of the 17th Century. The

hilt of the sword consists of a hand grip that is protected by a guard, to protect the hand during combat. At the end of the hilt is the pommel, which acts as a counterweight to the blade, thereby giving balance to the sword and allowing for greater speed and manoeuvrability during combat. Running down the centre of the curved blade is the fuller. This groove lightens the weight of the blade and enables it to be easily removed from the body of a victim.

With the introduction of firearms, the cutlass became redundant as a weapon, but remained in use for ceremonial purposes.

Parts of the cutlass

Blade -The back of the 80cm blade is blunt; only the curved side has a sharp edge

Hand grip

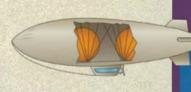
Awood or leathercovered hand grip was often replaced by cast iron when used at sea.

Pommel At the top of the hilt, this adds balance to thesword.









INDUSTRY & INDUSTRY & INVENTION

152	The age of piracy
	The truth behind piracy

- 156 Cutty Sark
 A tea clipper that could out-sail its competition
- **The Mayflower**Discover what life was like on this pilgrim voyage
- **The Titanic**Learn what caused this unsinkable ship to sink
- The steam engine
 The technology used to power Britain
- **The Flying Scotsman** A look inside the locomotive
- **The Mallard**Introducing the fastest steam locomotive on Earth
- **The Model T**The car that brought motoring to the masses
- **Airships**How these ships stay in the air
- **The blast furnace**Learn about the heat needed to produce iron and steel
- 174 Chinese earthquake detector

The tool used to measure the Earth's movements

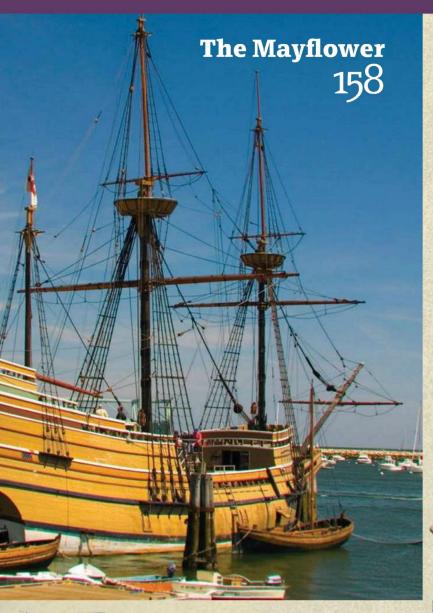
Jethro Tull's seed drillThe essential agricultural invention explained

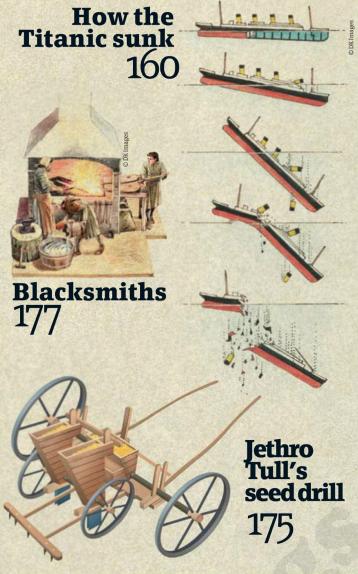
- 175 Water pumps
 Delivering water way before the tap
- **Early calculators**The mechanisms behind these early number crunchers
- **The plough**An essential invention for cultivating land
- **Self-heating food cans** Keeping food warm
- **Blacksmiths**Skilled craftsmen that created a range of important objects
- **Record players**Bringing music to the world
- **The first computer**Find out how Babbage's machine worked
- **Typewriters**See how they paved the way for modern word processors
- 181 Archimedes screw
 An ingenious method for transporting water
- **Hypocaust**Discover how the Romans heated their homes
- **Roman toilets**What were toilets like during Roam times?
- The wheel
 The invention that changed the world

- **Hallmarks**Explaining the application of metal impressions
- **Fountain pens**The writing instrument that's still popular today
- **Windmills**Grinding grain the old-fashioned way
- **Pendulum clocks**The mechanism that helps us track time
- **Zoetropes**Explaining the toy that makes the most of optical illusions
- 187 Cuckoo clocks
 An ornamental timepiece
- **Spinning jenny**The device that allowed yarn to be mass produced
- **Penicillin**An invention that redefined modern medicine
- **Safety razor**The secret to a close shave
- **Thatching**Building a roof
- **Electric battery**A way to create electricity
- **Davy lamp** Lighting a 19th Century mine
- **Tide mills**Harnessing tide power















The age of piracy

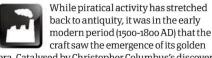
Over an 8o-year period, pirates lay waste to the New World, exploiting the lawless and wild nature of a region that was generating all manner of booty



Supplies

Food, alcohol (notably rum) and medical supplies were often held in the hull. Large quantities of gunpowder, guns and looted produce and precious metals were also carried. Supplies were rationed according to the pirate code.

A depiction of pirate Edward Teach (Blackbeard)



era. Catalysed by Christopher Columbus's discovery of the New World and then fuelled by a trading arms race to establish and exploit its vast riches by numerous world powers, pirates ruled the seas of the Caribbean and Americas with an iron fist for a number of decades. Their activities not only had serious financial implications for the region and the powers competing for dominance (primarily the Spanish, English, French and Dutch), but also sculpted the geopolitical landscape, with settlements, ports and trade routes changing hands on a frequent basis.

Pirates emerged from the privateers of the 16th century, who roamed the New World looking for riches and adventure, often on behalf of a national backer (see 'Pirate trade' boxout). Opportunities for fame and fortune were in abundance and men from across the globe travelled to explore this dynamic new region en masse. Indeed, the scale of this new territory was immense, with everything from the top of modern-day North America down through the Caribbean and on to the northerly coast of South America literally up for grabs to whomever held the biggest gun.

This fact, along with a wider pattern of Western inter-nation conflict (largely between protestant and catholic nations) generated a level of war and lawlessness that had not been seen for hundreds of years. Constructed settlements were frequently razed to the ground, ports were completely ransacked and massive naval battles were commonplace. Any territory that was held by a nation was done so at knifepoint and often on a razor's edge due to the scarcity of troops and difficulty in sourcing replacements from across the Atlantic Ocean. In many respects, as is common in the human pursuit of power and wealth, chaos reigned supreme.

Out of this chaos the Golden Age of Piracy was born, a period of 80 years lasting from 1650 to 1730 where every nation, every settlement and every trade route was at severe danger from being attacked by one of many infamous and brutal pirate lords. These included many of the men (and women; see the 'Famous pirates' boxout) that today represent the entire profession, celebrated and

revered in both literature and film. Pirates such as Edward Teach, commonly referred to as

'Blackbeard', Jack Rackham, known by reputation as 'Calico Jack' and Bartholomew Roberts, who through his violent and cruel deeds acquired the

nickname 'Black Bart'.

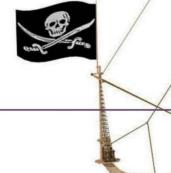
Importantly though, these figures were far from the melodramatic, larger-than-life characters more often than not presented in fiction. They were opportunistic and ruthless robbers, slavers and murderers, who wrought death and destruction wherever they went - Henry Morgan and his crew, for example, single-handedly burnt down and decimated Panama City, while Edward Low once burnt a French prisoner alive on a spit.

The Golden Age of Piracy came to an end arguably due to the signing of the Treaty of Utrecht in 1713 - a series of peace treaties between Spain, France, Britain, Portugal and the United Provinces - which, due to the ceasing of major warfare between nations, allowed many more military vessels and trained crewmen to be imported into the Caribbean. This, along with the total outlawing of piracy, led to the vast majority of pirates to be captured and executed, or outright killed in battle.



Design

Pirates rarely bought their ships and, as such, the types they used varied depending on what they could commandeer. Frigates were popular, as well as flutes and galleons, due to their increased storage capacities. The latter designs were also easier to sail, which often suited the largely untrained crews.



5 TOP FACTS FAMOUS PIRATES

The one that got away

The only pirate to have survived with his loot was Henry Avery, who is famous for capturing the Mogul ship Ganji-Sawai. He vanished in 1696, with conflicting reports of his final destination.

Buried

The cliché of pirates burying treasure comes from William Kidd's testimony before his execution that he had buried his vast looted fortune in an undisclosed location.

The fairer sex

Two of the most well-known pirates of all time were Mary Read and Anne Bonny, two women who took part in numerous brutal raids along with 'Calico Jack' Rackham.

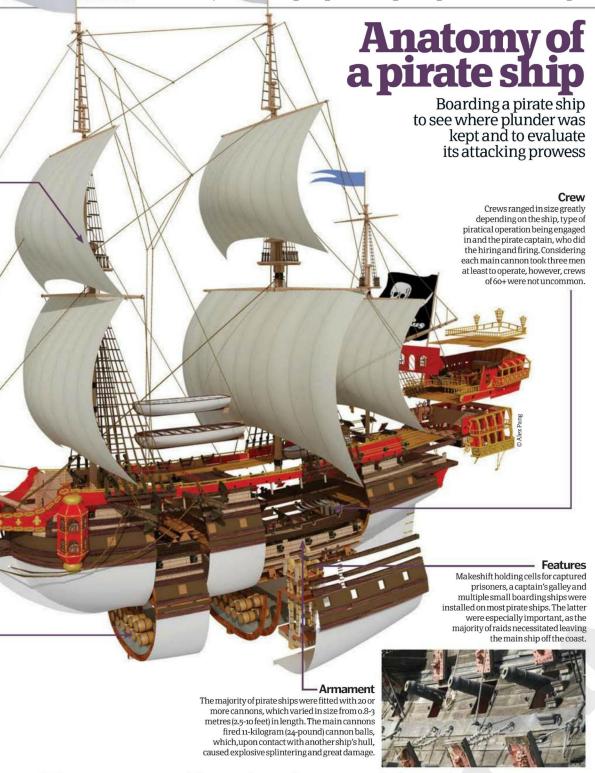
Romanticism

The Golden Age of Piracy was romanticised in the 19th century in classic literature like Robert Louis Stevenson's Treasure Island and J M Barrie's Peter Pan.

Decline

After the Treaty of Utrecht was signed, a host of skilled sailors flooded into the Caribbean to swell the navies. This was a key factor that ended the age of pirates.

Well-known privateer Henry Morgan was knighted by the British and made governor of Jamaica



"Pirates emerged from the privateers of the 16th century, who roamed the New World looking for riches and adventure, often on behalf of a national backer"

Pirate code

Contrary to popular belief, most pirates lived by strict rules. Here are a few examples

Every man has a vote in affairs of moment; has equal title to the fresh provisions, or strong liquors, and may use them at pleasure.

Every man to be called fairly in turn, on board of prizes. But if they defraud the company to the value of a dollar... marooning is their punishment.

No person to game at cards or dice for money.

The lights and candles to be put out at eight o'clock at night: if any of the crew, after that hour, still remained inclined for drinking, they were to do it on the open deck.

No striking one another on board, but every man's quarrels to be ended on shore, at sword and pistol.

No boy or woman to be allowed among them. If any man be found seducing any of the latter sex, and carried her to sea, disguised, he is to suffer death.

Desert the ship or quarters in battle is punished with death or marooning.

To keep their piece, pistols and cutlass clean and fit for service.

No man to talk of breaking up their way of living, till each had shared one thousand pounds.

The musicians to have rest on the Sabbath Day, but the other six days and nights, none without special favour.



Industry & Invention

Piracy



Pirate trade

The explosion of valuable goods in and out of the New World generated the vast majority of piratical activity of the period

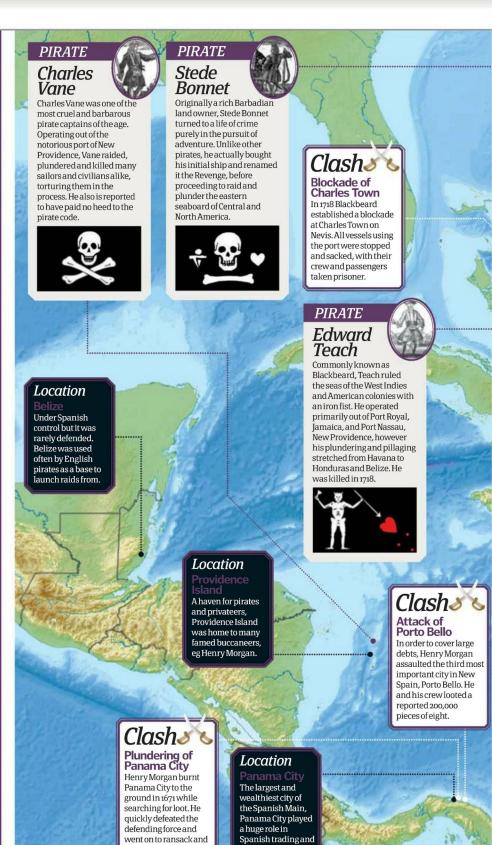
Catalysed by Christopher Columbus's discovery of the New World in 1492, the Caribbean and the wider Americas as a whole became an area of intensive trade and exploitation, with the West's major powers each vying to establish themselves in the region.

The Spanish were the first to make significant inroads in the area, being granted the Spanish Main by the pope in 1493. This huge area allowed them to establish numerous large trading ports and settlements including Panama, Cartagena, Santiago and Santo Domingo. From this dominant position, by the 1550s the Spanish were exporting vast quantities of silver, which fuelled their powerful empire. Further, this head start enabled them to deeply integrate the ports of the New World into their world trade routes.

Despite the majority of the New World being under Spanish control in the early to mid-16th century, due to its epic scale and vast distance from Spain, the country struggled to protect its new assets, leading to rival nations such as Britain, France and Holland gaining footholds. In addition, after news spread of the staggering quantities of valuable goods being carried across the Atlantic – as well as the general lawlessness of the area – piratical activities grew exponentially.

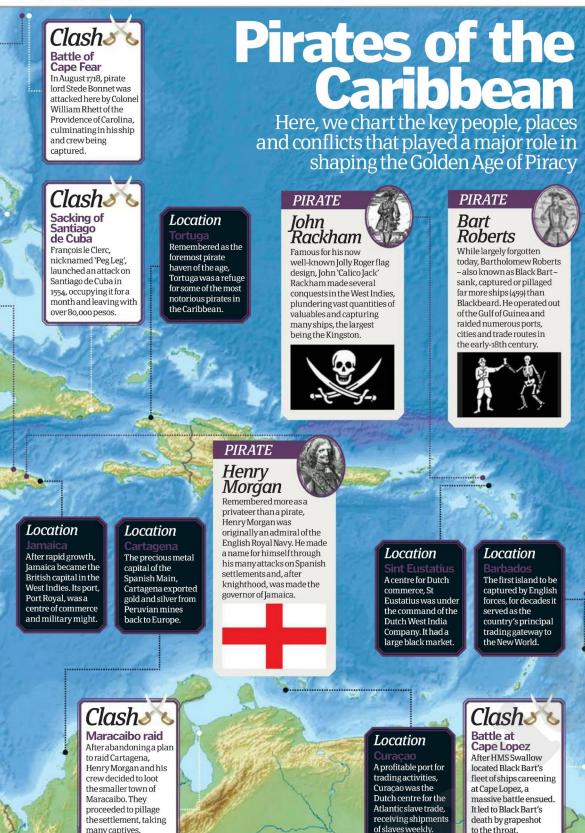
Interestingly this new pirate trade was initially legal, with notable military commanders and apolitical privateers hired to disrupt and loot trade routes, ports and settlements under an enemy's control. Henry Morgan is probably the most famous example of this practice, with the British crown granting him free licence to ransack and pillage the Spanish Main without consequence. Indeed, Morgan's efforts were so highly regarded, they earned him a knighthood and he was made governor of Jamaica.

By the mid to late-16th century, however, this game of one-upmanship had catalysed a new breed and culture of exploitative piracy, with rogue individuals commanding large fleets of ships that could rival those used by national navies. With limited policing powers and the establishment of several pirate havens such as Tortuga, a golden era of piracy had begun and would remain unchecked until the 1730s.



military activities.

pillage the city



Nations

The countries that brought about both the dawn and the demise of pirates

England



The English, despite the Treaty of Tordesillas,

quickly established numerous colonies throughout the West Indies, building a substantial presence in Barbados and Jamaica. During the Golden Age of Piracy, Port Royal, Jamaica, became a popular base for both English and Dutchsponsored privateers and many pirates even used the islands to launch attacks.

Spain



After the 1494 Treaty of Tordesillas, the majority

of the Americas had been decreed by Spanish-born Pope Alexander VI to belong to Spain. As such, by the mid-16th century, Spain had created the Spanish Main, a New World empire that included everything from present-day Florida, down through Central America and on to the north coast of South America.

France





The French rapidly tried to establish themselves in

the New World, building bases on the islands of Guadeloupe, Martinique and Saint Barthélemy. Famously though, they took control of the island of Tortuga in 1660, which was to become a privateer and pirate haven, hosting such notable figures as Henry Morgan, who used the island to recruit new crew members.

Holland



Curaçao was the equivalent of the English port at Barbados for the Dutch. It was a large settlement with a host of fortifications from which to defend the region. In addition, Dutch forces established additional bases on the islands of St Eustatius and St Martin, which became hubs of the sugar and slave trade.



Cutty Sark

The world's last intact tea clipper trading ship, the Cutty Sark epitomised the tailend of the age of sail, built to negotiate cross-continent trading routes with great speed



The Cutty Sark was an English clipper-class ship used predominantly to transport tea from China to

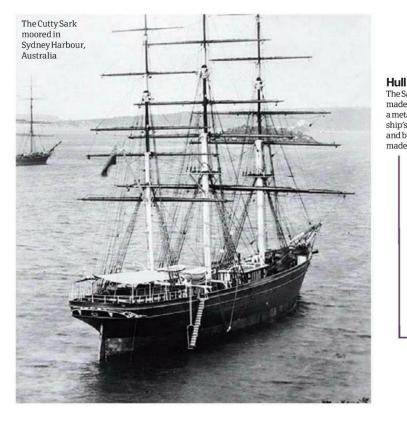
England. It was built for speed, with a narrow hull, a wide, forward-raked bow and a square rig on a three-mast setup. These factors enabled the ship to cut through rough waves with greater efficiency than pre-existing trading vessels, allowing produce such as tea, cocoa, coal and wool to be rapidly transported cross continent for expedited delivery (for the time). In fact, the high speeds attainable by clipper-class ships led to the formation of the 'Race of the Tea Clippers', an annual event where various crews battled it out to bring in the first tea shipment of the year.

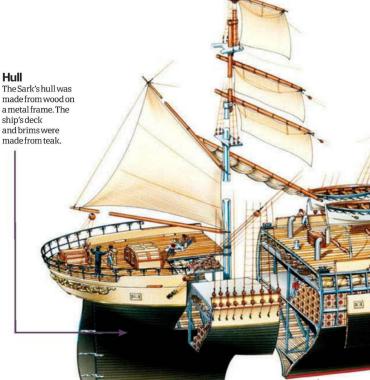
The Cutty Sark was - and still is today - a prime example of the tea clipper. With planking, deadwoods, stem and sternpost made from American rock elm, a bespoke iron frame, a deck made from teak and solid brass bolting throughout, the ship was one of the most expensive and advanced clippers at sea. This build quality was ensured by its shipbuilder's determination to outsail the other great clipper of the age the Thermopylae, something that it would proceed to do no less than five times during its career. Luckily, despite the ship falling into poor condition, numerous refits and restorations mean that today its condition remains unchallenged worldwide.

Unfortunately, as with many tools and technologies, the age of the Cutty Sark/clipper was not to last. The invention of the steam engine had led to increasing mechanisation throughout the Industrial Revolution and by the late-19th Century steam-powered ships were becoming financially viable to the mass-market. This, in partnership with the opening of the Suez Canal - which created a shortcut between Europe and Asia not traversable by sail-powered ships - caused clippers to be slowly phased out. As such the Cutty Sark was sold in 1895 and re-rigged in Cape Town, South Africa, returning to England in the Twenties to serve as a training ship.









5 TOP FACTS THE CUTTY SARK

Races

The Cutty Sark was designed as a merchant vessel, primarily to transport tea from China. Due to the product's popularity, annual races were held to bring the year's first tea to England.

Shirty

2 The Cutty Sark's name translates as 'short shirt' in modern English. The name was taken from the famous poem by Scottish poet Robert Burns, Tam o' Shanter.

Vool

In the early-20th Century the Cutty Sark was bought and redesigned to act as a ship to transport wool. As such, its homeport was switched from London to Lisbon, Portugal.

ry

In the early-Fifties the Cutty Sark had fallen into disrepair through lack of maintenance. But in 1957 it was restored and positioned in a dry berth near Greenwich, London.

Fire

In 2007 the Cutty Sark was set alight by vandals, leaving it with extensive damage. Luckily, much of the vessel had been dismantled for restoration. The ship reopened in April 2012.

DIDYOUKNOW? The Cutty Sark was moored under Krakatoa just two years before it erupted



Time waits for no clipper

There are only two other 19th-Century clippers still around, though they are fast decaying



City of Adelaide

Built: 1864

Fate: Sunk/salvaged

Position: Irvine, Scotland

Designed to transport passengers and merchandise between England and Australia during the latter's colonisation, the City of Adelaide is today the oldest surviving clipper in existence. During its heyday the Adelaide made 23 annual return voyages to South Australia and, consequently, it is estimated that 250,000 modern-day Australians can trace their lineage to a passenger on the ship. The ship was accidentally sunk while in Prince's Dock, Glasgow, in 1991 and, while salvaged in 1992, is now a severely dilapidated wreck. As with the Cutty Sark, the Adelaide is an A-listed protected structure.



Amb<u>assador</u>

Built: 1869

The Cutty Sark transported primarily

tea, wool and coal, however other

foodstuffs were carried as the ship

was capable of reaching destinations with great speed, reducing spoilage.

Fate: Beached

Position: Estancia San Gregorio, Chile

Built in the Lavender Dry Dock on the River Thames during 1869, the Ambassador was designed to transport tea from China to England. A frequent contestant in the great tea races of the day, the Ambassador was one of the fastest clipper ships, with a personal-best time of 108 days to complete the journey. After its tea-trading days, the Ambassador was used to transport wool and other products around the world. Unfortunately, in 1899, the ship was in a state of disrepair, with its then owner unable to pay for its restoration. As a result, it was beached in Estancia San Gregorio, Chile, where it remains to this day.



The Mayflower

Discover what life was like on board the ship that took the Pilgrim Fathers to America



The Mayflower is one of the most famous ships associated with English maritime history. After transporting the Pilgrim Fathers to a new life in America during

1620, the Mayflower was often regarded as a symbol of religious freedom in the United States. Originally, however, the Mayflower was a simple cargo ship that was used for the transportation of mundane goods – namely timber, clothing and wine. While statistical details of the ship have been lost, when scholars look at other merchant ships of this period they estimate that it may have weighed up to 182,000 kilograms. It is suggested that the ship would have been around seven metres wide and 30 metres in length.

The ship's crew lived on the upper decks. All in all, 26 men are believed to have manned the Mayflower on her legendary journey. The Master or Commander was a man called Christopher Jones: he occupied the quarters situated at the stern of the ship. The regular crew lived in a room called the forecastle, which was found in the bow – accommodation was cramped, unhygienic and highly uncomfortable. It was constantly drenched by sea water and the officers on board were fortunate in that they had their accommodation in the middle of the ship.

During the historic voyage, the Mayflower carried 102 men, women and children – these Pilgrims were boarded in the cargo area of the ship, which was deep below deck where the living conditions led to seasickness and disease. The Mayflower set sail from England in the July of 1620, but the ship was forced to turn back twice because a vessel that accompanied it began to leak water. Many problems affected the Mayflower and her crew during the voyage. There were serious threats from pirates,

but it was storm damage that was to prove problematic on this journey. In the middle part of the expedition, severe weather caused damage to the wooden beam that supported the ship's frame. Fortunately, however, it was repairable.

Several accidents also occurred, including the near drowning of John Howland who was swept overboard but then rescued. Less fortunate was a crew member who died unexpectedly – considered by all as 'mean spirited' – his demise was viewed as a punishment from God. A child was also born during the voyage: Elizabeth Hopkins called her son Oceanus.

The ship reached Cape Cod safely on 11 November 1620. The religious community, who were hoping to start a spiritual life in the New World, thanked God for their survival.



The Mayflower II replica docked at Plymouth, Massachusetts

The hold is the deepest

section of the ship. It was used to store cargo and

accommodate passengers.

"The Mayflower set sail from England in 1620, but was forced to turn back twice"



Beakhead

The beakhead is the protruding part of the foremost section of the ship.

Accommodation for the common sailors, the men slept here when not working on deck.



Old turkey

When the Pilgrims arrived in America, the natives taught them how to make canoes, grow maize and establish tobacco plants. They also introduced the newcomers to turkey, which was a native species of North America. For this reason the turkey became a traditional dish eaten at Thanksgiving.

DID YOU KNOW? It's thought that upon her return to England, the Mayflower was likely scrapped for her timber

a senior officer or guest.

Great cabin

Inside the Mayflower

The May flower was a cargo ship that could be divided into three levels, which included the deck with masts, lookout and rigging, and the lower decks, which contained the staff quarters, gun rooms and storage areas. Below this, the hold contained passengers.

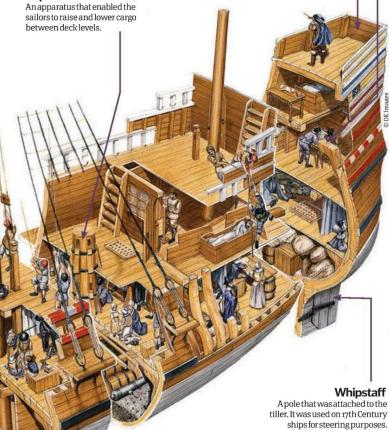
Poop deck

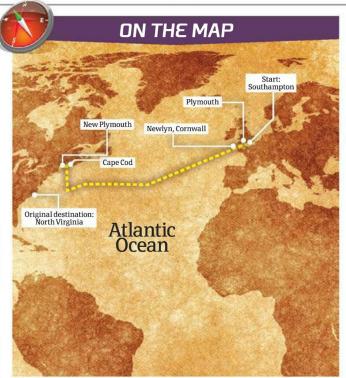
The quarters assigned to the ship's

Master, which had a second bunk for

Used for lookout and navigation, the poop deck provided the sailors with a wide view across the sea.

Capstan and windlass







Pilgrim Fathers

In 1620 a group of puritans arrived on the Mayflower destined for the New World. They were known as the Pilgrim Fathers. The Pilgrim Fathers were disillusioned with the ungodly and hedonistic behaviour of their native Englishmen and believed that America was a land of opportunity where they could start a new religious community.

They landed in New Plymouth, and began to build houses, but it is believed that half their population died during the first year of occupation. The New World was seen as a dazzling land and a second Garden of Eden, but in reality the environment was harsh and unforgiving. Some natives were helpful and taught the settlers how to survive this wilderness, and in 1621 they produced their first successful harvest. This was celebrated with the first Thanksgiving – in turn, this became a traditional feast day – and it is still observed as an American national holiday.

Learn more

To discover more about this historic ship, visit Passengers of the Mayflower (www.mayflowersteps.co.uk), Mayflower Ship of Pilgrims (www.thanksgiving.org.uk), or check out the book Mayflower: The Voyage That Changed The World (2005), Christopher Hilton, History Press.



The sinking of Titanic

One hundred years on, the story of how one of the world's greatest ships came to sink remains as mystifying as it is tragic. We set out to uncover what happened...



RMS Titanic was an Olympic-class passenger liner owned by British shipping company White Star Line and constructed at the Harland and Wolff

shipyard in Belfast, Northern Ireland. Titanic was the largest ship in its class, along with its sister ship the Olympic, and was capable of holding over 2,000 people. Its maiden voyage from Southampton, UK, to New York began on 10 April 1912. However, four days into crossing the Atlantic the ship glanced an iceberg and sank within three hours, resulting in one of the worst maritime tragedies in history. The remarkable story of how it sank is even more surprising considering some of the technological advances used on the ship, but despite being one of the most high-profile disasters ever, many mysteries around the actions of the senior officers on that fateful night remain unanswered and will likely stay so forever.

RMS Titanic was the second of three Olympicclass ships, the others being RMS Olympic (1910-1935) and RMS Britannic (sunk by a mine in 1916 after two years in service). For their time they were the largest ocean-liners in operation, and by far the biggest vessels in White Star Line's 1912 fleet of 29 ships. The three were all but identical in design save for a few very minor differences - mostly adjustments to Titanic to make it more luxurious for first-class passengers. They were built as a result of a rivalry between White Star Line and Cunard Line, the latter of which had just produced the fastest passenger ships around (the Lusitania and Mauretania). However, White Star Line's chairman, J Bruce Ismay, decided in 1907 to focus on size rather than speed, culminating in the building of these three behemoths.

The ships were constructed at Harland and Wolff in Belfast, which had been contracted to build ships for White Star Line for the previous five decades. The shipbuilder was given an almost unlimited budget to spend on the project and, by the end, Titanic and Olympic carried a combined cost of approximately £3 million (\$4.75 million). Construction of Titanic began on 22 March 1909, just a few months after her sister the Olympic. Over 1,500 men worked on the



The front page of *The New York Herald* reporting on the tragedy

Workers

200 firemen, stokers and trimmers were needed to keep the furnaces burning. Of these, only a handful survived the sinking of the ship.

two ships, with as many as eight dying during construction. In a development that would later prove crucial in the sinking of Titanic, the various steel plates of the vessel's hull were riveted together, as welding techniques were not yet sufficient in the early-20th century to hold together a ship of Titanic's magnitude.

One of Titanic's most innovative features, and also possibly somewhat responsible for its sinking, was its engines. Its two twin four-cylinder engines each

Inside Titanic

Deck by deck, take a look at how this mighty ship was put together

Decks

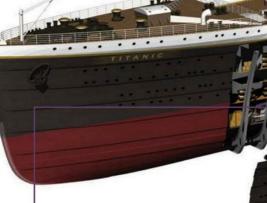
There were eight decks on Titanic. The uppermost housed the captain and his officers, and the next seven—lettered A through to G—housed passengers and crew in decreasing order of apparent social importance.

Lifeboats -

Titanic was equipped with enough lifeboats to save half the people on board, but due to the policy of 'women and children first' many of them departed half empty.

Bridge

The bridge and wheelhouse were in front of the officers' quarters towards the bow of the ship, with the former rising 2.4m (8ft) above the deck and the latter situated just above and behind the bridge.



Boiler rooms

Titanic's six boiler rooms housed the 29 boilers needed to power the colossal ship, venting steam through three of the four funnels.

measured almost 12.2 metres (40 feet), the largest of their kind. These powered two three-blade propellers – one port and one starboard – at the stern. The propellers were a hefty 7.2 metres (23.5 feet) wide and rotated in opposite directions, 75 times per minute, to lessen vibrations. An additional third propeller was positioned between the two main propellers for added efficiency. It was smaller than the other two and used steam from their engines to rotate up to twice as fast. However, unlike

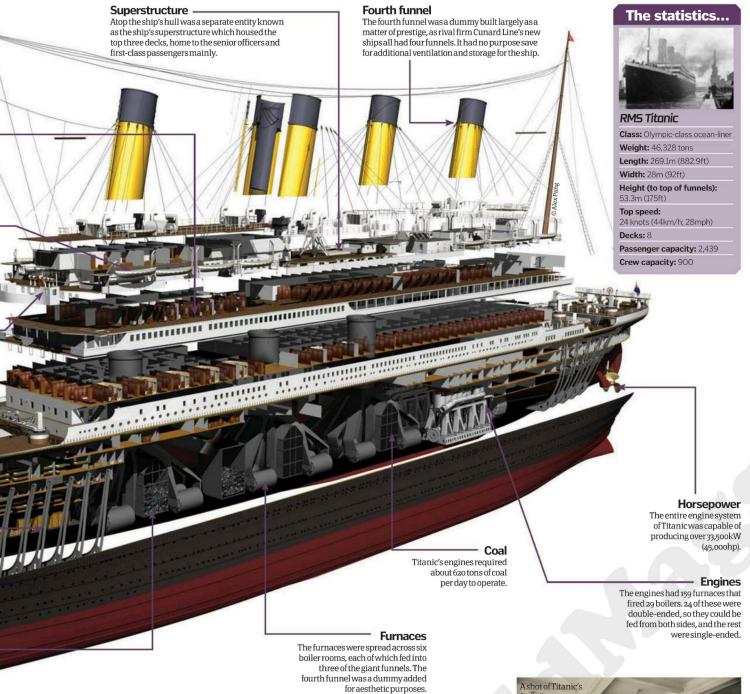


CAPTAIN SMITH 1850-1912

Edward John Smith began working for White Star Line in 1880 and it became tradition for him to skipper each of the White Star Line's new ships on their maiden voyage. He captained the Olympic in 1911 before Titanic in 1912. Despite being a bit of a maverick behind the wheel, he's often lauded as a hero after going down with the ship.



DIDYOUKNOW? RMS stands for Royal Mail Ship, an acronym used to designate vessels licensed to carry post by Royal Mail



the other two it was unable to rotate backwards, which would ultimately prove detrimental when Titanic came face to face with an iceberg. Steering of the ship was largely handled by a mammoth, if somewhat cumbersome, 100-ton rudder.

Titanic was 11 storeys tall and as long as six city blocks. Its interior decks, especially the lower ones encased by the hull, were a maze of narrow passages (known as alleyways) and doors that only a few officers on board were able to competently navigate.

Indeed, Second Officer Charles Lightoller recounted later that it took him 14 days aboard to be able to learn how to navigate from one end of the ship to the other. Considering Titanic sank just four days after it set off, with all the passengers on board never having set foot on the ship before, the complexity of its design brought obvious difficulties at the time of its sinking. Very few passengers in the steerage class were able to navigate their way successfully to the upper decks when Titanic began to sink. The story of





Industry & Invention

The Titanic



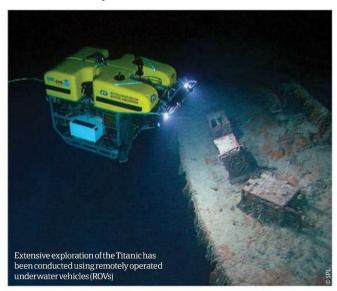
how it sank though is a combination of poor design, bad luck and misdirection.

At 11.40pm on 11 April 1912, lookout Frederick Fleet spotted an iceberg directly ahead of Titanic and telephoned the bridge. Quartermaster Robert Hichens was ordered to change course. However, the turning procedure took up to 30 seconds owing to several factors, including the inability of the ship's third propeller to rotate backwards and the attempted deceleration of the ship, resulting in Titanic striking a glancing blow on the iceberg. Indeed, it may even have been better for the ship to speed up rather than attempt to slow down, as doing the latter lessened its turning angle. It is estimated that if Titanic had maintained its speed, it would have avoided the fatal iceberg by several metres.

The impact with the iceberg produced a tear on the hull of Titanic more than 90 metres (300 feet) in length above the keel. The iron rivets used to keep the steel

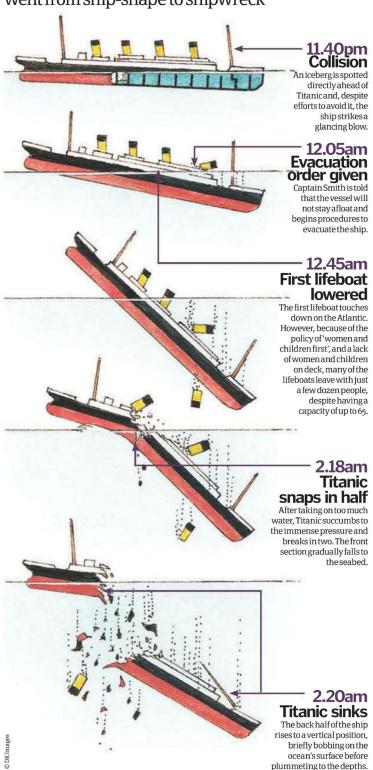
plates of the ship together were brittle and prone to snapping, while the plates themselves were weaker than modern steel due to impurities, meaning that they easily buckled under pressure from the iceberg. However, save for a loud bang near the point of impact there was little evidence of a collision throughout the majority of the ship apart from a slight shudder.

Water poured into the tear at a rate of about seven tons a second, flooding the Number 6 boiler room. Engineering staff worked to extinguish the furnaces and vent the boilers before they exploded upon contact with the icy cold water. The lower decks of Titanic were divided into 16 compartments, separated by bulkheads running the width of the ship. However, the bulkheads did not rise to the very top of the vessel, meaning that as water flooded each compartment it spilled into adjacent ones. Five compartments were breached by the iceberg; Titanic could only stay afloat with four flooded.



Stages of sinking

In just over two and a half hours Titanic went from ship-shape to shipwreck





SS Sultana

The SS Sultana exploded and sank on 27 April 1865. Up to 1,800 passengers on board died, the largest loss of life from a maritime disaster in US history.

MV Doña Paz

2 Up to 4,375 people died when the passenger ferries MV Doña Paz and MT Vector collided on 20 December 1987, the deadliest peacetime ferry disaster.

Wilhelm Gustloff

3 On 30 January 1945, German ship Wilhelm Gustloff was sunk by a Soviet Navy sub. Up to 9,400 died in the greatest ever loss of life in a maritime disaster.

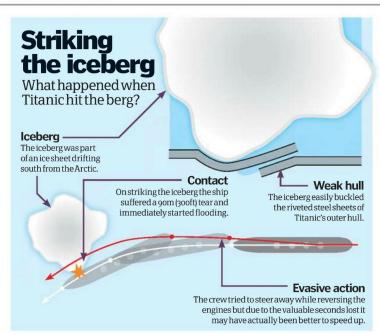
Yamato

This Japanese warship was the largest battleship ever constructed. It was sunk on 7 April 1945 by US torpedo planes. Of the 2,778-man crew only 280 survived.

Costa Concordia

Costa Concordia ran aground on 13 January 2012 near the Isola del Giglio. More than 17 people are thought to have died when the ship was taken on an inappropriate course.

DID YOU KNOW? Captain Smith narrowly averted crashing Titanic into the SS New York at the very start of its voyage





Due to the uneven rate of flooding, the ship listed five degrees starboard just minutes after the collision. After 45 minutes, over 13,000 tons of water had been taken on board the ship. The bilge pumps could only eject about 1,700 tons per hour, making it readily apparent that Titanic was doomed. The forward part of the ship gradually began to sink lower and lower into the sea. Two hours on, the vessel was tilted forwards at an angle of ten degrees. This greatly increased the rate of flooding and, by 2.18am, the stress on the keel became too great, resulting in the ship snapping in two. The front half descended slowly to a resting place at the bottom of the Atlantic but the back end rose to a vertical position in the water before crashing to the seabed at up to 48 kilometres (30 miles) per hour.

There were 2,206 passengers and crew on board Titanic. Of these, only 711 survived, despite the 20 lifeboats having a combined capacity of 1,178. There are several factors to blame, which include an inadequate number of lifeboats (although above the legal number for ships in 1912), poorly executed orders, lack of a ship-wide announcement system and inadequate information given to passengers. Indeed, up until the final hour many on board were convinced the ship would not sink. The high-profile sinking of Titanic sparked an overhaul of sailing safety measures, and a raft of changes were put in place to prevent such a disaster from occurring again. With the sinking of the Costa Concordia in January 2012, however, it's clear that even 100 years on there are still many lessons to be learned.



Interview Greg Ward

We speak to the author of *The* Rough Guide To The Titanic to find out his thoughts on one of the greatest peacetime maritime disasters in history

How did you become so interested in Titanic?

I've written lots of books over the years, but my interest in Titanic came from my mother-in-law. She's a film professor and she organised a conference for James Cameron's Titanic movie in 1999 that I went along to, and after that I got very interested in Titanic. The most interesting for me is why Titanic looms so large in popular culture, and why the anniversary is such a big deal.

What was the biggest challenge when researching?

There's been so much written about Titanic, so there's a basic story out there. However, I came with a fairly fresh view on it so I didn't have any preconceived ideas about the story. One thing you find is that so many people have a particular axe to grind, and there are all sorts of controversies and issues and debates that people like to take sides on and run with. The challenge was to realise there were so many stories with varying information that you just had to accept there are some things we don't know about the night Titanic sank. It's a disaster that happened in the middle of the night in the North Atlantic out of sight of the world.

What do you feel were the main factors that led to Titanic hitting an iceberg?

There were two big inquiries after the event, first in America and then Britain, which overlap with people who testified in both. They came to a similar conclusion, which the British one put fairly succinctly in that Titanic hit the iceberg because it was going too fast and couldn't get out of the way, as obvious as it sounds. They said the captain, EJSmith, was

pushing the ship too hard. Nobody at the time realised that was such a danger, and now anyone who caused the same event would be guilty of gross negligence. I think it's fascinating that the biggest and most advanced ship on the sea should be the one to hit an iceberg.

Why is the story of Titanic blurred in fact and fiction?

Most of the survivors did not reach New York for three days after the disaster. At that point everybody in the world had heard Titanic had sunk, but there had been no details of what happened. The newspapers had to fill the news so they basically made things up or went with what they assumed must have happened. Other stories were based on small anecdotes or isolated incidents. For example, the story of the band playing Nearer, My God, To Thee as the ship went down came from just one particular survivor who said it was the last thing she saw, but she left on the first lifeboat 90 minutes before the ship sank. It's unlikely they kept playing till the bitter end as is often reported.

Have we learned any lessons from the Titanic?

I watched a documentary about the sinking of the Costa Concordia recently, and there was footage of this stewardess saying everything is all right and there's no need for alarm while the ship was going down, and that passengers should return to their cabins. It's quite chilling to see that people are still not kept informed during such a disaster. The instinctive reaction of the Titanic authorities was that it's best to prevent panic, and it's scary to think it's exactly the same 100 years on.



The steam engine

For centuries the steam engine has been powering the British industry and even today steam plays a big part in the generation of electricity. We take a look at the men behind these major inventions



Until the start of the 18th Century, machines were powered by muscle, water or

wind, but steam power provided the potential for growth and flexibility on a mass scale. Steam engines facilitated the birth of large factories as production moved from rural riverbanks to industrial towns creating the formation of the cities we know today.

Steam power had been around for generations but it wasn't until 1698 that its application into industry was made. Military engineer Thomas Savery created a patent for raising of water by "the impellent force of fire" the first noted design of a steam pump. In 1712 Thomas Newcomen continued Savery's work and constructed the first successful steam engine, the atmospheric



engine. Its purpose was to rid coalmines of floodwater, allowing miners to reach new depths. It was considered so efficient for its time the design wasn't altered for six decades and the template was copied up and down the country.

British engineer James Watt came to largely represent the face of the steam movement, because his many patents prevented other engineers from furthering the progression of steampowered machinery until they expired in 1800, at which point a hungry new league of engineers took up the baton. Richard Trevithick pioneered 'strong steam' (steam at high pressure), meaning vapour could be 'compounded' and used repeatedly in a series of cylinders. Such a method was used in ships, railways and agriculture, inspiring various new vehicles and machines, from self-propelled steam boats and carriages to traction engines for the land and engine houses for grinding and processing grain.

By 1820 steam locomotives were commonplace and in 1830 'The Liverpool and Manchester Railway' opened as the world's first first inter-city passenger railway, engineered by George Stephenson and utilising locomotives that were designed by his son Robert, including the magnificent Rocket.

Towards the end of the 19th Century inventors found new ways to maximise steam efficiency and in 1884 Charles Parson's steam turbines opened new possibilities. Today steam-powered engines aren't in widespread commercial use, but some of their applications can still be seen from the production of electricity to underwater jet engines.



Rocket was acquired by



Any coaches attached to the Rocket were fastened by a couple at the back of the steam engine. Blast pipe
A blast pipe inside the Rocket
uses the steam exhaust to
improve the air draught
through the firebox where
the coal's burned.

A history of steam...

1698

Thomas Savery patents his machine for the raising of water by the "impellent force of fire", the first design of a steam pump.

1712

Thomas Newcomen builds the first practical steam engine. It is erected near Dudley Castle in Staffordshire. 1733

Savery's patent expires meaning more Newcomen engines could be built without 1769-1800

James Watt dominates steam-engine design and improvement. The Watt steam engine was the first to use steam at a pressure above atmospheric to drive

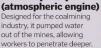
the piston.

1804

Arthur Woolf builds a compound engine that matches the work of Watt's machines using half the fuel. Head to Head



1. Newcomen's steam pump signed for the coalmining



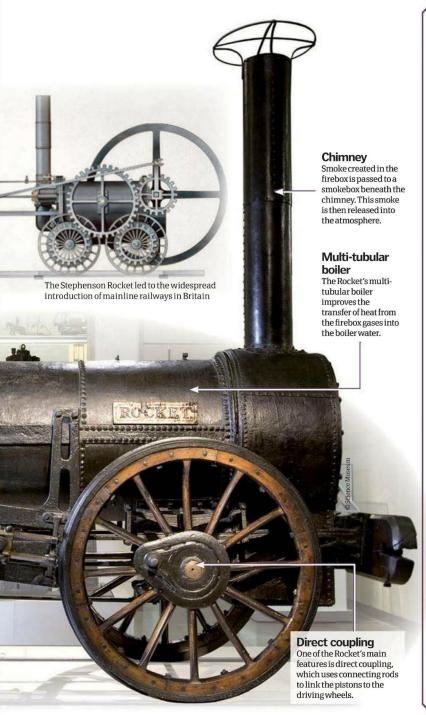


2. Great Western By the 1830s ocean-faring steamships appeared like Isambard Kingdom Brunel's Western, which employed high pressure steam



Hancock Enterprise carriage became the first self-propelled vehicle to operate a scheduled bus service for regular fare-paving customers

DIDYOUKNOW? The rest of Europe was desperate to snaffle Britain's steamy ideas and espionage became rife





The Science Museum **Ben Russell**

We spoke to Ben Russell, the curator of mechanical engineering at the Science Museum, to find out more about the early steam industry

Why was steam so significant to British industry?

Using a waterwheel to drive stuff only gets you so far. If Britain was to become this huge industrial nation, it needed a way of getting power to wherever people needed it-and steam was the way of providing that.

Why is Stephenson's Rocket such an icon of the steam age?

The Rocket was built for the Rainhill Trials in 1829, intended to choose the locomotive design for the Liverpool Manchester Railway. It was competing against a number of other engines, but it won because it packaged together a whole series of innovations in engine design, and in doing so laid the basis for locomotive design up until the 20th Century.

What is the importance of Newcomen's steam pump?

If we didn't have enough coal the Industrial Revolution would have faltered early on [we might never have become the industrial capital of the world). This development depended on making a mine deep enough to get to deep coal reserves without the mine filling with floodwater. For the first time the engine was capable of providing a huge amount of power to keep the mines free of floodwater so they could get to that coal and produce sufficient coal to keep the industry ticking over.

How significant was James Watt's contribution to the history of steam power?

Watt died in 1819 and even then he and his son had spent a lot of time building this 'Watt myth' that he's the bloke who created modern Britain. There was a lot of myth-making and many engineers were written out of the story of the development of the steam engine. When Watt died, the workshop at his house in Heathfield, Birmingham, was left untouched until the 1860s and preserved as it was when he left it.

In 1924 the house was demolished and it was [offered to] the Science Museum. We have an entire room with 6,500 objects in it. You're standing on the original floorboards, looking through the original window, opening the original drawers... It's like a proto-shed because, as nowadays, people have stuff in sheds that sits gathering dust, which is exactly what Watt did except the projects he was working on provide an outstanding physical record of his work. He could've had an equally successful career as a potter, chemist or surveyor as steam engineer. So Watt was a very multitalented bloke.



120 horses turning chain pumps, or the equivalent of about 2,000 men with buckets doing the same work

Richard Trevithick becomes the first British engineer to use highpressure 'strong' steam. The machine revolutionised transport.

The first proficient commercial steam boat was launched; Robert Fulton's North River Steamboat.

First commercial locomotive constructed by Matthew Murray, Eight ears later there were 20 steam locomotives in ervice

Goldsworthy Gurney built a steam carriage the roads motoring along

The steam turbine replaced steam power in its previous form with Charles Parson's axialflow turbine.

The end of the longest working atmospheric engine. Built by Francis Thompson in 1791 it stood at Pentrich Colliery.



The Flying Scotsman locomotive
Inside the film star, record-breaker and national treasure



The Flying Scotsman began life as No 1472, an A1 Pacific-class locomotive. The Pacific class had a 2-6-2 arrangement of wheels, which enabled it to carry a bigger boiler, making it suitable for

long-distance passenger services. Under ownership of the London and North Eastern Railway Company (LNER) it was renumbered the 4472 and christened the Flying Scotsman.

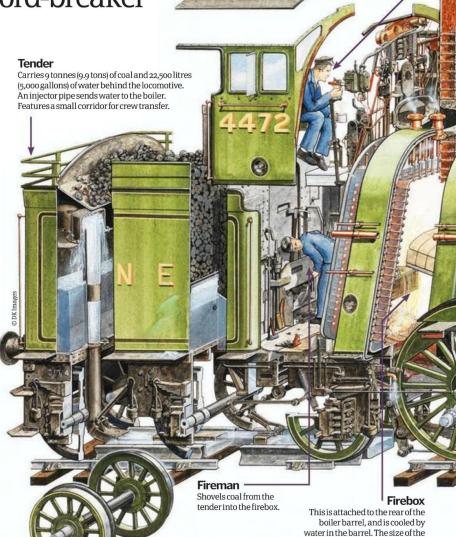
When it broke down and was taken out of regular service it was the ideal candidate for putting on show at the British Empire Exhibition in 1924 and 1925. It was an immediate hit with the public, and its fame was sealed when in 1928 it launched the regular 10am non-stop Flying Scotsman Express Service from King's Cross, London, to Waverley, Edinburgh.

To cope with the 631km (392-mile) route the locomotive pulled a special eight-wheel tender that carried great quantities of water and coal. Since the crew had to be replaced during the eight-hour journey without stopping, a special corridor was built in the tender to allow the relief crew to pass between the train and the cab.

The Flying Scotsman became even more famous on 30 November 1934, when it travelled at 160.9km/h (100mph) breaking the world speed record.

In January 1947, the Flying Scotsman was converted to the A3 class that incorporated a larger boiler with a higher boiler pressure and, a year later, it was re-designated as the No 60103 under the ownership of British Rail. In 1963, it was sold off and went through several owners before being rescued by the National Railway Museum, York, in May 2004.

The Flying Scotsman Express Service



Service begins

JUNE 1862

The East Coast mainline from London to Edinburgh is used to run the first Special Scotch Express, departing at 10am with a journey time of ten and a half hours.

Faster

Rivalry between rail companies brought the journey time to as low as seven and a half hours. As this racing was dangerous it is agreed to set the time at eight hours 15 minutes

firebox is 19.9m2 (215 sq ft) and the

A1 class

A total of 75 A1-class locomotives were built in the Twenties and Thirties and most vere named after racehorses All were eventually converted to the improved A3 class.

Boiler tubes

Hot gases from the

water in the boiler.

firebox pass through

the tubes, heating the

Price tag

The Flying Scotsman originally cost £7.944 to build. Including the purchase price and restoration work the National Railway Museum has spent £4 million on it since 2004.

Longest record

The Scotsman was taken to Australia in 1989 where it set a new record for the longest non-stop steam locomotive journey of 711km (442 miles) from Parkes to Broken Hill.

Long distance

The Flying Scotsman passenger locomotive had travelled an impressive 3,340,998.14km (2,076,000 miles) when it was sold by British Rail in 1963.

A sound start

The locomotive starred in The Flying Scotsman feature film. Released in March 1930 it was one of Britain's first films to include a 'talkie' soundtrack.

Nº 1866

DONCASTER

1938

RAILWAY Cº

DIDYOUKNOW? The Scotsman returned to the tracks in 2011, but discovered cracks mean it's out of service until late–2012

Streamlining

Since the engine was so tall, the cab, dome and chimney had to be virtually flush with the boiler to avoid hitting bridges between Newcastle and Edinburgh.

Driver

The driver uses the throttle to control the regulator in the steam dome to increase or decrease the amount of steam sent to the cylinders.

Steam dome

The water in the boiler turns to steam under high pressure, and rises to the dome. The A1 boiler had 18 opsi while the A3 boiler increased it to 22 opsi.



The Flying Scotsman was not only known for speed but luxury too

Sir Nigel Gresley and the LNER

Herbert Nigel Gresley (19 June 1876-5 April 1941) served his apprenticeship at Crewe Locomotive Works. His leadership and engineering skills led him to become the chief mechanical engineer of the London and North

Eastern Railway Company (LNER) based in Doncaster.

He designed the A1, and upgraded them to the A3 class. In 1935, he introduced the A4 class that included the Mallard, which gained the world speed record by travelling at 202.7km/h (126mph) in 1938. He also worked on steering gear for ships and, in total, designed 27 classes of steam locomotive.

Gresley was always eager to test new innovations and incorporate the best ideas from Europe and America into his designs. In 1936 he was knighted by King Edward VIII in recognition of his industry.

Chimney

In 1958, the Scotsman was fitted with a Kylchap exhaust system that evenly mixed the steam from the pistons and gases from the boiler tubes to improve performance.

Cylinders

The Scotsman has three cylinders on each side. A Gresley-conjugated valve gear system orders the operation of the pistons inside the cylinders.

Cranks and connecting rods

The movement of the pistons is transferred through these rods to the wheels. The diameter of the wheels is o.96m (3ft 2in) for the first four, 2.03m (6ft 8in) for the coupled set and for the trailing wheels 1.12m (3ft 8in).

The statistics...

The Flying Scotsman

Sir Herbert Nigel Gresley

Manufacturer:

Doncaster Railway Works

Year built: 1923

Class: A3

Length: 21.6m (70ft)

Width: 2.8m (9ft 3in)

Height: 4m (13ft)

Weight: 97.5 tonnes (107 tons)

Boiler pressure: 220psi

Top commercial speed: 108km/h (67mph)

Top record speed:

160.9km/h (100mph)

Status: Owned by the National

Railway Museum, York



1900

Luxury

Passenger comfort is enhanced by the introduction of dining cars, heating and corridors linking carriages.

Official recognition

This service had been nicknamed the Flying Scotsman since the 1870s. LNER now officially gives the service this name and gives the 4472 locomotive the same title.

1932

Speeding

The restricted journey time of eight hours 15 minutes was officially reduced to seven and a half hours.

23 MAY 2011

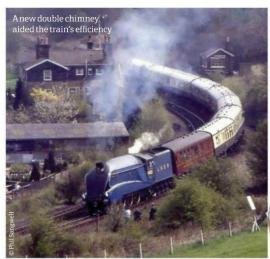
A new beginning

The Class 91, electric locomotive 91101 starts an Edinburgh to London weekday service. It takes just four hours to run the route.



The Mallard steam locomotive

Beautiful, sleek, powerful, and to this day the fastest steam train on Earth. Introducing the Mallard steam locomotive...

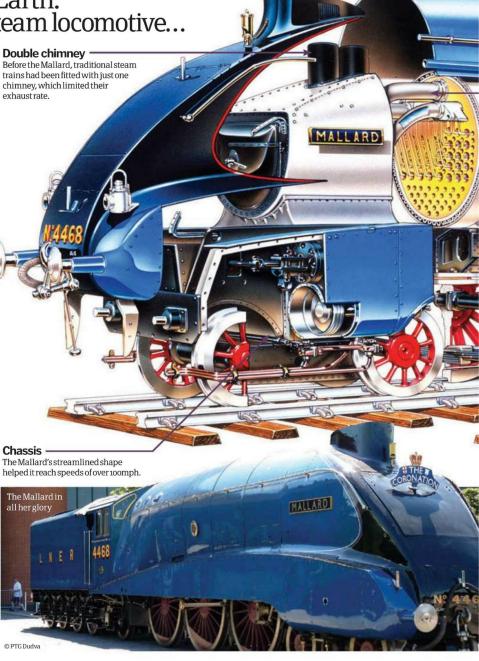


Steam engines use coal-powered boilers to generate steam, which is funnelled under pressure down a series of pipes, known as a steam circuit. This steam moves pistons that are

attached to the train's wheels, and this is what drives them. The exhaust steam is then released via the funnel at the front of the train. The system is effective, but if the boiler is put under too much pressure it can explode, devastating the engine and killing or injuring the crew. Likewise, the exhaust has to be as efficient as possible, drawing steam and exhaust fumes out to both minimise pressure in the system and to allow more steam to be drawn through at a greater speed.

This is where the Mallard excelled, everything about this locomotive was designed for speed. The streamlined body, tested in a wind tunnel, meant it could run at over 100mph for extended periods of time. However, the secret of its success lay in its double chimney, which allowed for faster venting of exhaust gases at speed and its Kylchap blastpipe. Mallard was the first locomotive of her type to be fitted with this system from new. Its four linked exhaust pipes draw more exhaust gas through the system at a greater speed and with an even flow, minimising wear and ensuring that the boiler, steam circuit and pistons could work at maximum efficiency.

Mallard was literally built for speed, and on 3 July 1938 it reached 202.58km/h (125.88mph) on East Coast Main Line, south of Grantham. Mallard still holds this record, making it the fastest steam locomotive in the world, not to mention one of the most beautiful.



Head to Head SPEEDY TRAINS



1. Mallard
The world's fastest steam train, the Mallard's top speed was 202.58km/h (125.88mph) due to pioneering technology



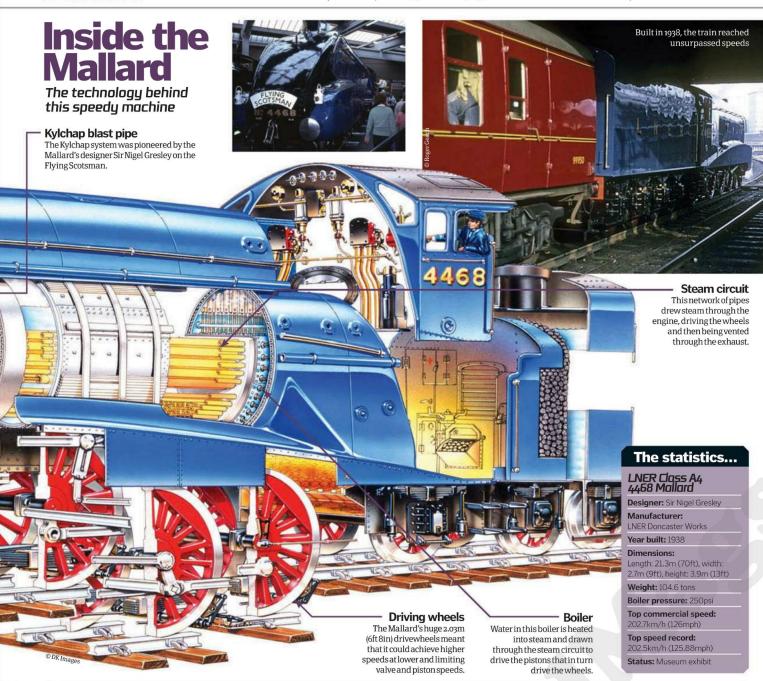
2. Shanghai Maglev
Opened in 2004, the Shanghai Maglev transport system reaches speeds of up to 430km/h (268mph).



3. The bullet train

Japan's bullet train, or Shinkansen, a network of high-speed railway lines, can reach up to 440km/h (275mph).

DIDYOUKNOW? The Mallard steam locomotive operated from 1938 until 1963, when it was withdrawn from service



The Kylchap blast pipe

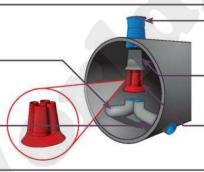
The Kylchap blast pipe used four stacked nozzles, the first taking exhaust steam, which fed into the second, where the exhaust steam was mixed with gas from the smokebox. This flowed into a third that added more exhaust gases and this mixture, then into a fourth, which led to the engine's chimney. This meant that the flow of gas was more even through the engine and greatly increased its efficiency.

1. First blast pipe

This pipe is the primary nozzle, which carried exhaust steam only.

2. Second blast pipe

That steam was mixed with gas from the engine's smokebox here.



5. Chimney

The mixture complete, it was vented through the engine's exhaust chimney.

3. Third blast pipe

More exhaust gas was introduced to the mixture in this blast pipe.

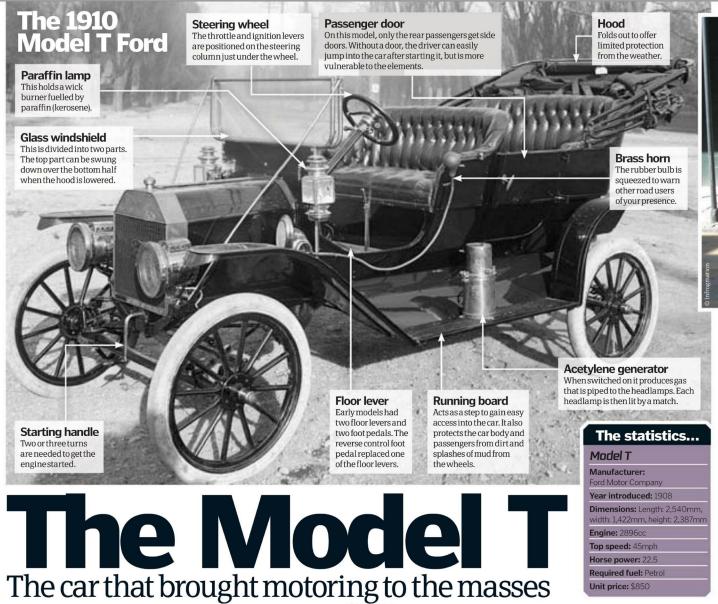
4. Fourth blast pipe

The fourth and final blast pipe to combine the mixture led up to the chimney.



Industry & Invention

Model T Ford







By today's standards, Henry Ford's Model T has many unusual

characteristics. Before you can jump into the driver's seat, you have to turn a hand crank at the front of the car to start it. This is a hazardous process as the hand crank can break your thumb if the engine backfires, and if the throttle lever on the steering column is not set properly it will run you over as soon as it starts. Fortunately, an optional electric starter was introduced in 1919.

The Model T has three foot pedals and a floor lever. To drive off, you increase the throttle lever, move the floor lever forwards from its neutral position and depress the clutch foot pedal on the left. As you pick up speed, you can move from

first to second gear by releasing pressure on the clutch pedal. To stop, simply reduce the throttle, press down the clutch pedal, depress the brake foot pedal on the right and put the floor lever into neutral. To go backwards you keep the floor lever in neutral and press down the middle reverse foot pedal.

Early versions of the car had brass acetylene lamps, and its ten-gallon fuel tank was mounted under the front seat. As this fed petrol to the carburettor using gravity, the Model T could not climb steep hills if the tank was low on fuel. The solution to this was to drive up hill in reverse.

Its engine is front mounted, and features four cylinders in one en bloc casting. This simple engine is relatively

Head to Head AUTOMOBILES



seater, Touring Runabouts were sold at a cost of \$900 each. The hood was an optional extra. They can nov sell for around \$40,000.



2. White Type E Model T and the internal combustion engine, the White Sewing Machine company produced a series of luxury, steam-powered touring cars.



3. Curved Dash Oldsmobile

built using mass production methods in 1901, long before Ford improved these methods. It cost \$650.

DIDYOUKNOW? Henry Ford said you can have any colour Model T as long as it is black



Just as its modern counterparts developed different styles and shapes over the years, so too did the Model T

Model T production centres

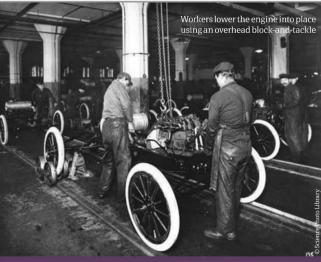
- 1 Highland Park Plant, Michigan
- 2 Trafford Park, Manchester, UK
- 3 Walkerville, Ontario, Canada
- 4 La Boca, Buenos Aires, Argentina
- 5 Geelong, Victoria, Australia
- 6 Berlin, Germany





easy to run and maintain. The first models were runabouts with open bodies and a hood that can be folded down. Lots of different car and truck bodies were later fitted to the Model T chassis by Ford and other companies.

Since the Model T was equally at home in town or as an off-road farm workhorse, and available at the cheapest price possible, it quickly dominated the USA and made motoring an essential part of our lives.



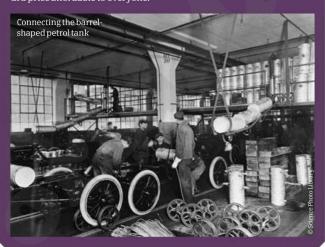
Mass production
The revolutionary methods used by
Ford opened up a world of possibilities

Mass production using a moving assembly line was the key innovation that made the Model T so successful. Car production had been largely pitched at the luxury market with hand-built bespoke models being the norm. Henry Leland, who worked for Cadillac, pioneered the standardisation of car components, and moving production lines were used in Chicago slaughterhouses. The genius of Ford was to integrate these methods and reduce the production of the Model T to 84 key areas.

The chassis of the car was run along a track and each worker carried out a very simple and repetitive production task, before it was moved on to the next work area. The engine and other components were made in a similar manner before being added to the chassis. This slavish process made it possible to reduce the time to make one Model T from 12 hours eight minutes to 93 minutes.

As early as 1914, Ford's mass production techniques produced 300,000 cars with 13,000 workers compared to the 66,350 workers at all the other car companies who only produced 280,000 cars.

From 27 September 1908 till the end of production on 26 May 1927, 15 million Model Ts were made. The Model T met and exceeded Henry Ford's vision of creating a simply designed car using the best materials at a price affordable to everyone.





Airships

Combining both methods of a ship and a hot air balloon, we investigate how an airship flies

Airships use a combination of different gases in order to get off the ground, fly and descend. Today mostly helium gas is used to fly the

lighter-than-air (LTA) craft, which although more expensive than hydrogen, was adopted as the non-flammable alternative after the infamous Hindenburg accident.

The helium-filled ship holds several 'tanks' of air known as ballonets. Because air is heavier than helium, all the pilot needs to do is open the air valves to release it and create positive buoyancy so the airship elevates. Once in the open skies the pilot controls the airship in flight much like a submarine under water, using a rudder to steer, adjusting the elevators to ascend and descend and throttling the engine (which provides forward and reverse thrust) to angle it into the wind.

At higher altitudes the air pressure outside the LTA decreases and so the helium in the envelope expands, to maintain pressure the pilot pumps air into the ballonets. This technique is also employed to descend, as filling the ship with more 'heavy' air makes it negatively buoyant and therefore sinks lower in the sky, or bring it in to land.

Rigid airship

Air valves (inside envelopes)

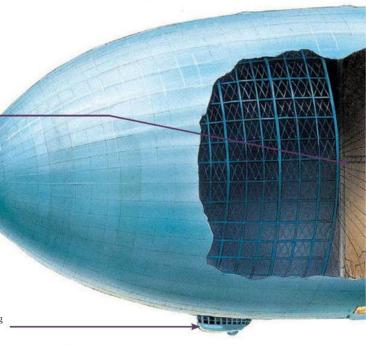
Four air valves adorn an airship, and the pilot uses these to vent the air from the ballonets to ascend – as well as add to it to descend.



This is the area where the passengers and crew sit. On average most airships can accommodate two pilots and around half a dozen passengers. On the Hindenburg the ship was so large it featured several sleeping rooms, a dining room, library and lounge.

Ballonets

Ballonets are the air-filled bags located inside the helium envelope. Most _____ airships have two ballonets.

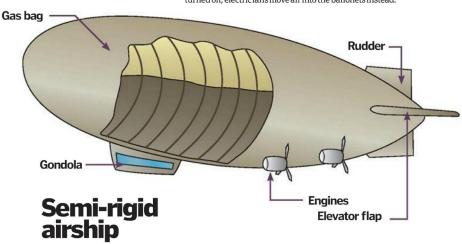


Air scoops

The air scoops channel air from the propellers into the ballonets when needed. This is used to descend the air craft. When the engines are turned off, electric fans move air into the ballonets instead.

The first airship

While the first hot air balloon was invented in 1783 by two
French brothers – Jacques-Etienne and Joseph-Michel Montgolfier – the first powered airship was not constructed until many decades later in 1852. Henri Giffard built the first, which consisted of a 143-foot cigar-shaped gas bag with a propeller. It was powered by a three-horsepower steam engine. Just under half a century later in 1900 Count Ferdinand von Zeppelin of Germany invented the first rigid airship and therefore his name and work lives on.





Multi-talented machines

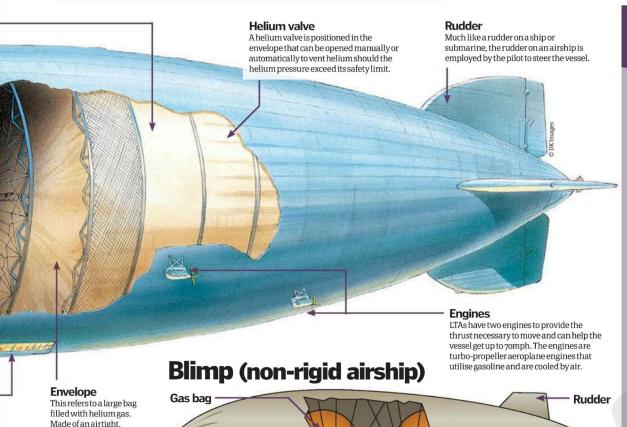
Airships can stay elevated from a matter of hours to a stretch of several days. making them ideal for research or for watching sports events and so on. In recent times scientists have been adopting the method of transport to study whales, thanks to their less disturbing nature than helicopters, boats and planes.

Hindenburg

The German Hindenburg airship took off from Frankfurt in May 1937, taking just two and half days to reach New Jersey. The ship measured over 800 feet in length and weighed 242 tons. Accommodating a rigid design, it was filled with hydrogen - a much cheaper gas than the helium used today. On arrival it hovered tentatively over its landing area as 200 ground crew attempted to

retrieve it with its landing lines. A small burst of flames was spotted on the upper fin and in just 34 seconds - reacting with the highly combustible gas - the ship was transformed into a huge fire ball. Some of the people on board jumped to safety and landed on the sand below, but 13 passengers, 22 crew and one ground man were killed in the accident.





Steering

lightweight fabric, the envelope holds between 67,000 to 250,000 cubic feet of helium depending on the size of the airship.

If you'll imagine a submarine gaining positive and negative buoyancy to move up and down in the water by taking on and losing air, the same principle applies to airships but in reverse. To elevate the ship the pilot releases air so it becomes lighter, and to descend in the air the pilot releases air from the ballonets into the envelope to make it sink. A rudder is used to steer the direction of the ship but the pilot can manipulate the engine to move forwards and backwards, or to angle it into the wind.

Gondola



Elevator flap

Engines





1. Hindenburg

long to an excess of 360ft (120m) and are traditionally cigar shaped in appearance. They feature an internal metal frame and gas-filled bags.

SEMI-RIGID



2. Norge

Facts: A semi-rigid airship features a pressurised gas balloon (known as the envelope) that is attached to a lower metal keel

NON-RIGID



3. MetLife, Fuji or Goodyear blimp

Facts: Perhaps one of the most common styles of airship seen today, the non-rigid airship or blimp - features a large gasfilled envelope.

Learn more

For more information about airships and zeppelins you can visit www.airships.net for pictures, articles and a history of the Hindenburg and Graf Zeppelin crafts



The blast furnace

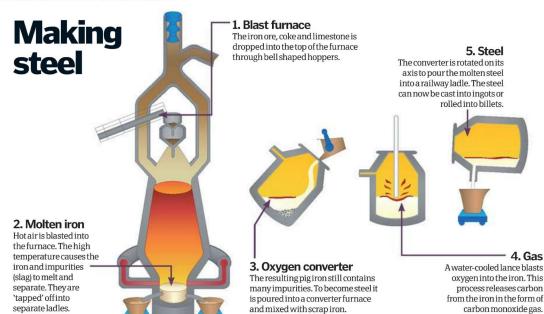
An enclosed chamber that uses high temperatures to produce iron and steel

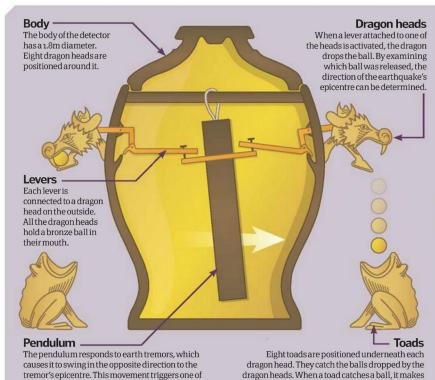
The blast furnace was a major catalyst for the Industrial Revolution as the smelting of iron kick-started the iron trade. Iron ore, coke and limestone are fed into the top of the furnace at a regular rate. As this moves down through the

As this moves down through the furnace it is blasted by hot air (up to 1,200°C). The coke burns in the hot air and acts as a fuel to melt the iron ore while the limestone causes the rocky material in the iron ore to become molten slag.

The molten slag floats on the molten iron at the base of the furnace. Separate clay taps are broken to pour off the molten slag and iron. The molten iron is usually sent to be made into steel before it cools off to form pig iron. Slag is dumped and used for road building.

Blast furnaces can run for several years before their brick refractory linings need replacing.





Chinese earthquake detector

The world's first instrument for measuring the seasonal winds and the movements of the Earth



a sound to warn of the earthquake.

It looks like a huge ornamental vase, but in reality, it is an earthquake detector invented by the Chinese philosopher and astronomer Zhang Heng in AD 132, during the Eastern Han Dynasty.

The 'Houfeng didong yi' as it was called, is described in the 5th Century 'History of the Later Han Dynasty', but an actual working version of it has not survived. This has led to much speculation about the details of how the pendulum mechanism worked inside the detector.

Heng built it on the principle that when winds are compressed into narrow spaces with no means of escape, they cause any obstacles to be dislodged and tossed "with a deep murmur."

His device was claimed to be so sensitive it detected an earthquake 400 miles away, which was confirmed when a rider was dispatched to the area.

the levers surrounding the pendulum

Jethro Tull's seed drill

One of history's greatest agricultural inventions explained



A key invention during the British Agricultural Revolution, the seed drill allowed for a semi-automated, controlled distribution and

plantation of wheat seed. Designed by renowned agriculturalist Jethro Tull in 1701, the drill went on to spawn many other mechanised planters and ploughs, which many of today's agricultural tools and vehicles are descendents of.

The drill-which was made from elm wood and consisted of a wheeled wooden frame worked by carving three channels into the earth into which seeds were dropped

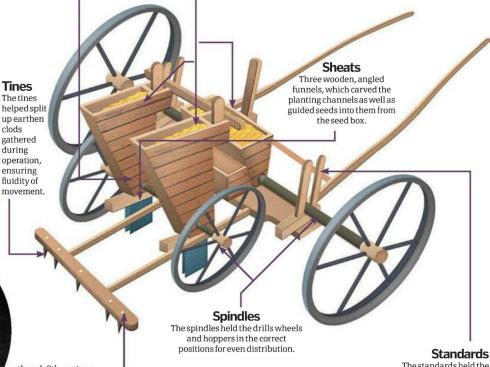
from containers at regular intervals. The seeds, once dropped by the horsedrawn drill, were then covered by the harrow (a trailing bar), which gathered soil and evenly deposited it over the channels. For a detailed breakdown of Tull's seed drill, check out the accompanying illustration.



hoppers, these boxes distributed the seeds at set intervals.

Hoppers

The drill's hoppers were chute-like containers that held the seeds en masse. They dropped from here into the seed boxes for scattering.



17th and 18th-century agriculturalist and

inventor of the seed

drill, Jethro Tull

Tines

The tines

gathered

ensuring

fluidity of

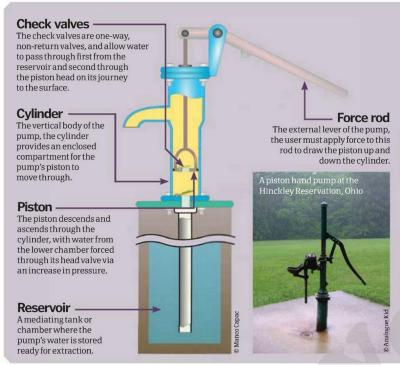
during operation,

clods

Harrow

The harrow covered the seeds with soil once deposited in the cut channels

The standards held the spindles-and therefore the drill's wheels - perpendicular



How do water pumps work?

We break down a manual water pump to see how it delivers H₂O



There are many different types of water pump, however the most common are positive displacement varieties, such as the manually operated piston pumps which are often found in parks, as well as developing countries.

Positive displacement pumps work by trapping water from a central reservoir and then forcing its volume upwards into a discharge pipe. This is achieved most commonly through the use of a valved piston and cylinder, which when combined (see illustration), draw water via suction up into a cylinder, before redistributing it through a descending valved piston head into an expanding higher chamber. When the piston begins to rise, its own valve is forced shut by increased pressure within the higher cylinder chamber, while the cylinder's reservoir valve is pulled open by a release of pressure in the lower chamber. This allows pockets of water to be continuously drawn up from an underground source to an outlet on the surface.

Historically, water pumps were invented to optimise the retrieval of water from town wells, which previously had employed simple but labour-intensive bucket-on-rope methods.



Industry & Invention

First calculator/Self-heating cans/Ploughs

How did early calculators work?

The world's first mechanical number cruncher explained



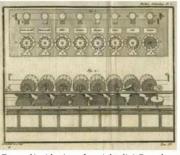
Blaise Pascal invented his shoebox-sized calculator to assist his father with his

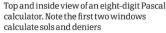
business. The Pascal calculator consists of numbered setting wheels that are linked through gears to numbered drums. From the left each wheel represents units of 1, 10, 100, 1,000, 10,000 and

100,000. To add 4 and 9, you dial 4 on the first wheel, and then dial 9. After reaching 9, the gearing mechanism turns the drum in the second window representing units of 10 to 1. The machine then displays 13 as the answer. For use with French currency, the first two wheels are fitted with 12 and 20 spokes to represent deniers and

sols, with the remaining wheels counting livres.

It is possible to use the device to subtract numbers (using the nines complement method), multiply by using repeated addition, or divide numbers by using repeated subtraction. Unfortunately, its complexity and cost hampered its widespread use. *









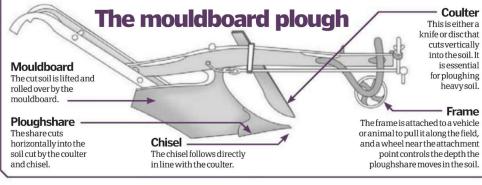
The essential tool for cultivating the land



The first plough was no more than a stick dragged in the ground. The ancient Egyptians developed the use of animals like oxen or cows to pull a plough, and the Greeks added wheels to this design for greater control and manoeuvrability.

Ploughs simply moved aside the soil to break it up and create a furrow to plant seeds into, but in the 1600s, the Dutch improved ploughs using a mouldboard that turns over the top soil and deposits it over the previous furrow. This design was more efficient and easier to use, allowing more land to be cultivated.





Self-heating food cans

Discover the easy way to heat and eat



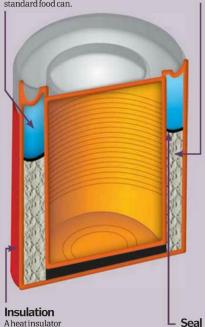
Wilhelm Espenhayn and Friedrich Oswald Hunger gained a US patent for a self-heating can in 1906, and the principles of

its operation have barely changed since. The can itself essentially consists of two outer or inner compartments, one containing quicklime (calcium oxide CaO), and the other containing water. To heat the food or drink inside the can, the seal between the two compartments is broken. Within seconds, the two substances create an exothermic reaction, which means they release energy in the form of heat. In the space of five minutes, this reaction will heat the can's contents to 40 degrees Celsius.

Inside the selfheating can

Water is contained in a compartment surrounding the upper part of the standard food can.

Ouick lime This is contained in a compartment surroundingthe lower part of the can.



Aheatinsulator

surrounds the can to prevent heat radiating outwards and away from the contents of the can.

Awaterproofseal separates the water and quicklime compartments

5 TOP FACTS WORKING WITH METAL

He who hits black metal

The word 'smith' comes from 'smite', which means to hit. The prefix 'black' was used because the iron to be forged would develop a layer of black oxides as the metal was worked.

Iron: the metal of choice

Wrought iron is a strong metal that's resistant to rust and easy to work. Although bronze was also used by blacksmiths, it was harder to come by and also more expensive.

Location, location

Depending on where they lived blacksmiths had different roles. Village blacksmiths would serve small rural communities, while a castle smith would make weapons and repair armour, etc.

Forging in the dark

The forge was a very dark place, but this was intentional so the blacksmith could better judge the temperature of the metal with which he was working based on its colour.

The terms blacksmith and farrier were once interchangeable, but

now the latter is solely associated with shoeing horses

Hard as steel

Blacksmiths added carbon to the iron to create steel, which made it harder. This carbon came in the form of bone dust or powdered hooves, which could be added to the hot metal and cooked.

DIDYOUKNOW? In the Middle Ages, some towns saw the techniques used by blacksmiths as a dark art and banned it

The role of blacksmiths

Medieval blacksmiths were skilled craftsmen, but how did they come to cast such useful and attractive objects?



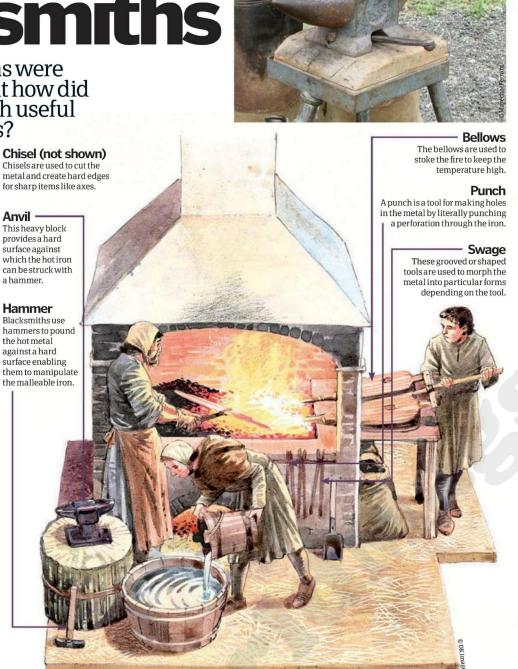
A blacksmith is a metalworker who works specifically with the so-called 'black' metals like iron – unlike gold and silversmiths

who work with their respective 'white' metals. Working in a room known as a forge, the blacksmith could turn hot iron into useful items for hunting, fighting and farming, as well as beautiful objects for decoration.

Whereas modern metalworking techniques include melting iron right down until it can be poured into moulds, medieval blacksmiths 'forged' metal by heating it until partially melted and malleable, and then shaping it with a variety of specialised tools. Using a hammer, the iron could be drawn (lengthened) by beating the metal against the anvil. This would flatten and/or widen the metal, thereby 'drawing' it out. A technique called upsetting was used to increase the thickness of the metal in one dimension through hammering the cold end of the object with the hammer to make the malleable hot end shorter and thicker. To bend the metal it was placed over the horn of the anvil and struck with the hammer to achieve a smooth curve.

The blacksmith was a valued member of medieval society who had dealings with many sections of the community because their skills were used for a diverse range of applications. Among other professionals, they were employed by dentists, doctors, undertakers and armourers alike who had need of metal implements and specialist objects. The blacksmith therefore also needed to be fairly entrepreneurial to run a thriving business that catered to all walks of life.

The emergence of the blacksmith enabled empires to develop and flourish as they could now wield the equipment and weapons to dominate during battles and advance civilisation – until the Industrial Revolution, that is, when technology advanced further still. Nevertheless, the blacksmith craft remains a respected and skilled profession to this day, and their significance to history should not be underestimated.



Made by the blacksmith: Swords Daggers Lances Arrowheads Armour Shields Tools Rivets Nails Hinges Locks Keys Torture devices Chains Knives Pokers Ornaments Jewellery Horseshoes Gates



Record players How sound is recorded and replayed from vinyl

Vinyl records are the audio storage media of yesteryear. You can think of them as MP3 players that simply store sound using a different system; older hard disk drives use magnetism to store this information, reading and writing using an arm that sweeps back and forth across spinning magnetic plates. Flash-memory music players (read: iPods and their contemporaries), meanwhile, make use of transistor technology to store digital music, while compact discs have tiny pits pressed into the silver layer by a laser, which can be read by a CD player.

Records work in a very similar, if a more tangible, way to the latest playback devices, though the same principles behind 19th-century phonographs can be seen at work in modern turntables. The tiny grooves in the record vibrate a crystal in the stylus (needle) at the end of the arm as it moves across the record's surface. The resulting microscopic jolts move a metal bar that squeezes a piezoelectric crystal, generating an electric signal. The signal is fed to the amplifier that interprets it, then sends it out to the speakers which replicate the original sound.

Today's records are made of vinyl, pressed from a metal 'mother' that is cut using highly specialised machines. But even though the recording is of a much higher quality, you can still spin the turntable by hand to hear the record play without any intervention from modern technology.



dawn of digital music recording, Thomas Edison discovered that by attaching a needle to the diaphragm of a telephone receiver, a visual representation of the sound could be drawn when the needle vibrated along a cylinder covered in tinfoil. By attaching a horn and rotating the cylinder by hand, the sound could then be reproduced. Edison put his work on the phonograph

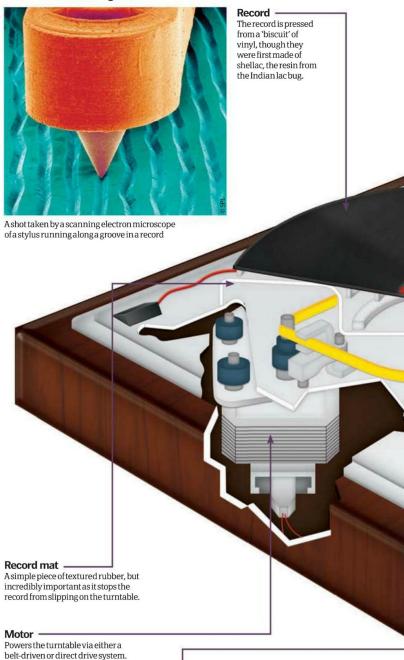
electricity. In the meantime, Emile Berliner stepped in to create a more practical machine that used flat black discs, but could only play and not record. This was the gramophone and its records could be mass-produced via Berliner's Gramophone Company. The basic format for sound recording remained the same up until the Eighties, when cassette tapes became standard.

Stylus

Tipped with a tiny diamond or

within the grooves on a record.

hard mineral, the needle moves



Cartridge

This is a plastic housing for the

stylus that converts the vibrations

from the contact with the record

into electrical signals

WORLD'S MOST EXPENSIVE RECORD

John Lennon and Yoko Ono's Double Fantasy album sold for over half a million in 1980. Why? It was owned by Lennon's assassin, Mark Chapman.

DIDYOUKNOW? The first recording of a human voice was made in 1860 by Édouard-Léon Scott de Martinville

From disc to music

A look inside a record player and highlighting the key components



World's most-

Probably the mostrecognised record in the world (and beyond) is the Golden Record that was placed aboard the Voyager 1 and 2 spacecraft. It is a 30-centimetre (12-inch) copper phonograph plated with gold and on it is recorded sounds, music and greetings from Earth in 55 languages, including: Beethoven's Fifth Symphony, "Hello from the children of planet Earth" in English and the sound of crickets and frogs. It is encased in an aluminium jacket and includes a needle and cartridge along with instructions for any intelligent extraterrestrial life that happens upon Voyager on how to play the record. The record is designed to be played at 16-2/3 revolutions per minute - half the speed of the 33-1/3 standard for a commercial 12-inch vinyl. Since its launch in 1977, Voyager 1 has travelled nearly 18 billion kilometres (11 billion miles), making the Golden Record one of the few manmade objects to have left the solar system.

This mechanical arm, also known as the pickup, glides across the record with the stylus and delivers the electrical signals into the amplifier.

Servo This highly engineered box of tricks controls stylus pressure and helps prevent the arm from skating across the vinyl disc

Turntable

Modern turntables keep the record spinning at a constant 33-1/3 or 45 rpm, for 30cm (12in) and 18cm (7in) records, respectively.

Suspension

A series of springs positioned beneath the turntable is designed to provide stability to ensure smooth and accurate audio.

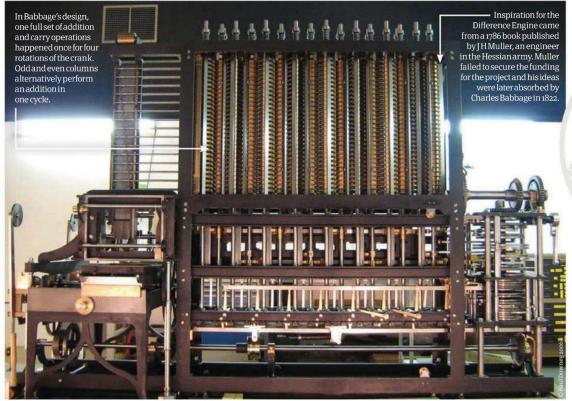
Disc-size selector

This needs to be specially set to accommodate the diameter of a record and is connected to the auto/manual operating lever.



Industry & Invention

First computer



The first computer

Charles Babbage invented the first computer, called the Difference Engine. How on earth did it work?



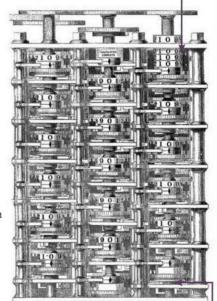
The Difference Engine is the first automatic, mechanical calculator designed by British mathematician

Charles Babbage, who proposed its construction in 1822 to the Royal Astronomical Society. He suggested the machine would employ the decimal number system and would be powered by turning a handle, as a method to calculate mathematical tables mechanically, therefore removing the high rate of human error.

At first Babbage received financial backing from the British Government, but this was later pulled when no apparent progress had been made on constructing the device. The inventor went on to design a more general analytical engine and then later in 1847 an improved engine design – the Difference Engine No. 2.

From 1989 to 1991, using Babbage's plans of this second version, the London Science Museum constructed Babbage's envisaged machine. Faithful to the original designs the machine consists of over 8,000 parts, weighs five tons and measures 11 feet in length. In 2000 the printer which he plotted to accompany the engine was added and together performed as the inventor had intended over a century before. The completion of the machine ended a long-standing debate as to whether Babbage's designs would've worked.

Babbage designed the first mechanical computer – the Difference Engine – that eventually led to the invention of the first mechanical computer and as such is widely accepted as the 'father of the computer'.



Despite the fact the machine looks archaic by modern standards the basic architecture is similar to the contemporary computer. The data and program memory are separated, operation was instruction ruled, the control unit could make conditional jumps and the engine had a separate input/output unit.

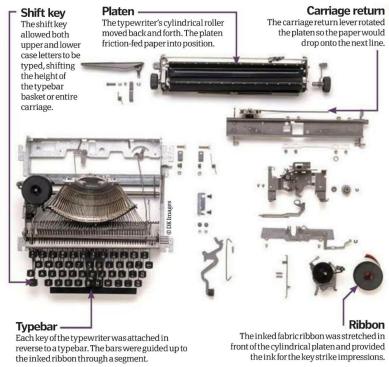


Born in London in 1791, Charles Babbage was a mathematician, philosopher, inventor and mechanical engineer. He was formerly tutored as a child in Devon and Middlesex, and in 1810 he attended Trinity College where he claimed to be disappointed in the mathematical education available. Teaming up with John Herschel and George Peacock, among others, Babbage and company formed the Analytical Society in 1812. In 1814 he married Georgiana Whitmore and moved to Dudmaston Hall in Shropshire where Babbage engineered the central heating system. The couple had eight children, three of which survived to adulthood. In 1827 Charles' wife, father and at least one son died, it was these sad events which caused the inventor to suffer a mental breakdown, delaying the construction of many of his machines. He died aged 79, it is thought of 'renal inadequacy, secondary to cystitis'. Half of his brain is preserved in the Hunterian Museum in the Royal College of Surgeons, London.

Typewriters

Mechanical devices used to type text onto paper, typewriters paved the way for modern word processors





Mechanical typewriters work by imprinting inked key heads – containing one or more letters, numbers or symbols – onto a sheet of paper one after the other

to form lines of text. To achieve this, five vital standardised parts are implemented into each typewriter's body.

At the bottom-centre of the unit a mechanical keyboard is connected to a basket of typebars. Qwerty keyboard layouts are common, although other layouts have also been used. When their

corresponding key is be raised, guided by a segment channel vertically up to the unit's ribbon. The ribbon is a strip of fabric that was covered with the type's ink. When struck by the head of the typebar – onto which letters, numbers and symbols have been affixed – the corresponding letter is then printed onto the sheet of paper.

The typewriter's paper is held in place around a cylindrical tube referred to as a platen, which itself can move from left to right horizontally within a carriage system. The platen can be incrementally

wound at the end of each line of text with the carriage return. The carriage return is a lever positioned at the end of the carriage, which drops the paper onto the next line for continued text.

Finally, the basket of typebars can be shifted up and down with the shift key, allowing its user to move between lower case and upper case type. Raising the typebar up to the ribbon in a new position means a different part of the typebar's head can now strike the ribbon, imprinting a different letter, number or symbol.

Archimedes screw

An ingenious ancient method of transferring water from one plane to another



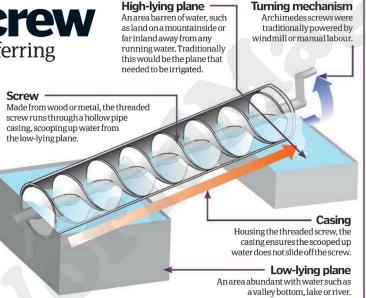
Attributed to inventor and polymath Archimedes in the 3rd Century BC, the

Archimedes screw works by utilising the angular frequency and speed of a rotating thread to transfer water from a low-lying plane to a higher one.

The machine consists of a hollow pipe angled at 45 degrees with a threaded screw encased within, which rotates once wound. The bottom of the cylinder is submerged in the water on the lower plane while the top end empties out into a channel or basin. As the screw

rotates, the screw scoops up water at the bottom and, as it is encased within the cylinder, is forced to slowly slide up the thread to the top and onto the higher plane. In addition, any water lost through the small gaps between the screw and the cylinder are recollected by the thread directly below the one that lost it, ensuring mechanical equilibrium while in operation.

Traditionally Archimedes screws were used for irrigation, allowing water to be artificially transported to ditches, and were operated by hand. Modern variants are now primarily used for drainage.





Hypocaust/Roman toilets

Hypocaust

What have the Romans ever done for us?



Hypocausts - an ancient Roman system of central heating-worked by raising the floor of a room

off the ground on a series of stone pillars (pilae stacks), thereby allowing hot air and smoke to be filtered under it through holes leading to an exterior fire and, consequently, supply a steady stream of heating to the house through convection. Smoke was prevented from entering the room by architects leaving holes in the

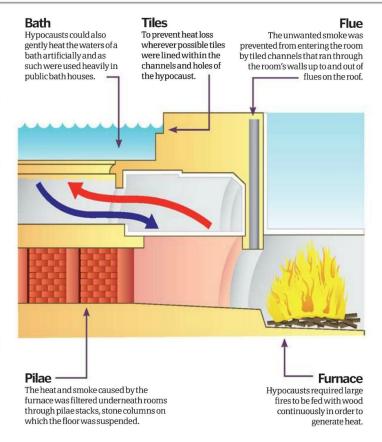
s a portion of its

surrounding walls, allowing it to filter through these enclosed spaces and out of flues onto the roof.

Hypocausts were labour-intensive to operate as a large exterior fire or furnace had to be supplied with wood to maintain heat levels. Because of this, hypocausts were often only a feature of public bath houses and large private villas owned by wealthy families. Their invention is often credited to Sergius Orata, a famed merchant and engineer of the Roman

> Republic, who specialised in designing and building Roman baths.

With fundamentals very much akin to the central and underfloor heating systems we have today, the hypocaust is often credited as one of the Roman's most forward-thinking and useful inventions, helping to increase the living conditions and hygiene of citizens considerably.



Roman to lets A flushing toilet can be found in every home, but it hasn't always been this way



Originally installed in the homes of the rich as a status symbol, and in army barracks to prevent

diseases spreading, the 'flushing toilet' was intended to rid the city of Rome of human waste and maintain good sanitation. By AD 315 the capital had 144 public toilets, predominantly housed within public baths.

The toilets were communal and typically featured a marble bench with a succession of holes. The bench was built over a channel of flowing water which would 'flush' the human waste away. Seven rivers were forced to run through the city's man-made sewers which served as a way of flushing the sewage out of Rome.

A shallower, narrower channel of water ran in front of the seats and was created as an off-shot from the main water source. Placed within this stream were sticks holding a sponge, ready for the Roman to wipe themselves clean after using the facilities.

In public baths and private homes the toilet seat itself was fashioned

The holes were made at the same

Sponge stream Anarrow stream flowed past the feet of the seated



Sewer

Underneath the bench of toilets was the sewer. The Romans forced seven rivers through the city to offer a constant flow of running water.

Flush

The constant running water meant that anything deposited into this channel was clearlyswept away out of the baths or private residences and out of the city.

Evolution of the wheel

Since its invention, how has the wheel evolved over the years?

Early humans in the Palaeolithic era (15,000 to 750,000 years ago) discovered that heavy, round objects could more easily be moved by rolling them than bulky, irregular ones. The realisation was made that some heavy objects could be transported if a round object such as a fallen tree was placed underneath and the heavy object rolled over it. However, diagrams on ancient clay tables suggest the wheel did not materialise for thousands of years until a potter's wheel was used in Mesopotamia (modern day Iraq) in 3500 BC.

The oldest wheel discovered so far was found in Ljubljana, Slovenia and is believed to date back to about 3200 BC, remarkably late for such a key invention. It was about the same time that the wheel was first used for transportation on chariots. With a need for greater speed and manoeuvrability, the Egyptians created the spoked wheel around 2000 BC, while Celtic chariots a millennium later employed iron rims for greater strength. However, the wheel remained largely unimproved until the 19th Century when Scot Robert William Thompson invented the pneumatic tyre, a rubber wheel using compressed air which paved the way for automobile and bicycle tyres.

Wheels through the ages

The wheel has been used extensively and improved upon throughout time but how have humans harnessed its practicality?



1. Keep rollin' Early Homo sapiens realised that round

objects could be easily moved by rolling them.



 $Their ancestors \, advanced \, this \, rolling$ technique into the transportation of large objects on cylindrical logs

3. A wheel of a time

The invention of the wheel and axle allowed a rolling log to be placed through a hole in a wheel to create a cart.



The world's highest Ferris wheel is in Singapore and rises 165 metres. That's almost twice as high as Big Ben.

4. Chariots of tyre

Influential in the evolution of the wheel as the chariots needed to move quickly, chariot racing led to the faster spoked wheel.



The invention of air filled rubber tyres allowed wheels to be much faster, sturdier and stronger, ultimately redefining transportation.





Hallmarks/Fountain pens

Hallmarks explained

Why are precious metals often impressed with these small icons and how are they applied?

Hallmarks are an official series of icons and numbers which are imprinted on to a variety of precious metals, such as gold and silver, to denote their purity and fineness. Any hallmark is determined and applied today by an assay office, an institution that specialises in assessing a metal's quality by formal metal testing.

Traditionally, hallmarks were administered by guilds, which were industrial groups set up to preserve the standards of a craft. This practice began in England in 1327, when King Edward III dictated that all silver articles must meet a purity rating of 92.5 per cent and delegated its enforcement to the Worshipful Company of Goldsmiths.

Due to the soft nature of assayed metals, the application of a hallmark is achieved via stamp pressing, which traditionally was executed by hand. Today, articles are commonly stamped with their hallmark via hydraulic presses, however laser marking is an emerging technology used for smaller, more awkward pieces.





Head to Head WINDMILLS OF THE WORLD



1. Enercon E-126

The largest turbine model built to date, with a hub height of 135m, rotor diameter of 126m and a total height of 198m.



2. Outwood post mill

Built in 1665 in Outwood Surrey, this is Britain's oldest working windmill . It was once one of a pair, the other collapsed in 1960.



3. Holland's windmills

The Netherlands are so closely associated with windmills that they have become part of their national identity. However, most of these windmills were used for drainage rather than for grinding corn.

DID YOU KNOW? Until Henry VIII dissolved the monasteries, villagers had to have their corn ground at their local lord's mill

Windmills

Before steam and electric power, windmills were used to grind grain

A windmill uses an array of sails to convert the energy of the wind. The horizontal motion of the shaft attached to the central hub of the sails is converted, through a gearing system, to turn the vertical shaft. The vertical shaft is attached to a runner grindstone. Beneath the rotating runner stone is the bed grindstone that is fixed in position. Grain is fed between the two stones and the grinding process produces flour. The fineness of the flour can be adjusted by using different grindstones or adjusting the distance between them.

The first designs used in Britain were basically post mills, which consisted of a wooden structure built around a vertical post. In 174 Edmund Lee invented the fantail that was mounted on the cap

the wind. Tower mills were made of brick and c reach a greater height and were not such a fire hazard, but were more expensive to

to a rotatable cap. 🥮

MIRIO TITTUDE

These sails have a lattice construction with windboards fitted on the inner half of the leading edge. This is known as a 'common' sail.

Cap

The sails are attached to the rotating cap of the mill. The horizontal shaft from the sails is called a windshaft.

Brakewheel

The brakewheel is mounted on the windshaft and turns with it. The cogs on its edge engage with the wallower wheel.

Wallower

This is mounted on the upright vertical shaft. The wallower engages with the brakewheel causing the upright shaft to turn.

Great spur wheel

The great spur wheel is mounted at the bottom end of the upright shaft and drives the stone nuts.

Stone nut

The stone nut engages with the great spur wheel. It turns a shaft that drives the runner stone.

Grindstones

The runner stone turns above the bed stone to grind grain. The flour from this process is dropped down chutes to grain sacks.

Catching the wind

The first windmills had vertical sails that were fixed to a vertical axis that turned a grinding stone. The horizontal axis design proved more efficient and powerful. The optimum speed for a windmill grindstone is 150 revolutions a minute; any faster is dangerous and slower is inefficient. To achieve this, sail cloths were attached to latticestyle sails to speed them up, or removed to slow them down. In the 18th Century sails featured adjustable shutters that could be used to control their speed.

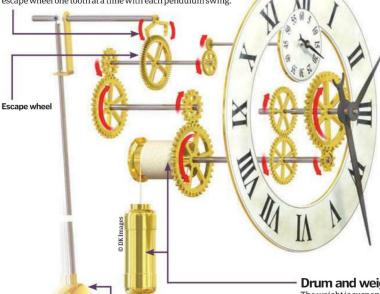
185



Pendulum clocks/Zoetropes

Anchor escapement

The action of the pendulum sets a sequence of gears and wheels in motion. The anchor escapement device moves round the escape wheel one tooth at a time with each pendulum swing.



When you start the pendulum swinging it sets clock mechanisms in motion. The pendulum consists of a rod or string with a weighted disc at one end. The length of rod greatly affects how long it takes to complete a full swing.

Drum and weight

The weight is suspended from a cord and wound round the drum. The weight unwinds slowly with every second that passes until it's fully unwound. The clock will then stop and the weight must be wound back on to the drum.

Mechanical pendulum clocks explained

How can a swinging mechanism accurately keep the time?



Galileo discovered that as long as a pendulum stays the same length and keeps swinging, the time it takes to swing back and forth is always the same. This makes a pendulum the ideal timekeeper.

When you start a pendulum swinging, it continues to swing back and forth because the forces acting on it aren't balanced. If you swing the pendulum one way, its weight, gravity and the tension in the string pull the pendulum back down towards the centre. However, as the pendulum swings back, its weight and velocity send it swinging back up the other way past the centre point. As long as there is an energy source, the pendulum will keep swinging with this precision indefinitely.

So from where does a pendulum get its power? Well, a weight is suspended from a drum that is attached to a series of gears. As the weight falls it turns the gears that each drive the different clock hands-ie, the second, minute and hour hands.

To control the speed at which the gears turn, however, a special escapement device allows each swing of the pendulum to release just one tooth of the gear at a time, giving the pendulum enough energy to overcome the friction of the swing. When the weight reaches the end of its tether, it needs to be wound back on to the drum again using a special key.



How do zoetropes work?

The optical toy that creates the illusion of moving images



Today when you go to the cinema or watch TV, what you are actually seeing is a huge number of consecutively photographed images, or frames,

displayed one after the other in very close succession. As each frame is individual there is a brief moment between each picture when there is nothing to see. If the series of images can be displayed at a high enough rate, however, these blanks, or gaps, between two pictures can become

so miniscule that the brain does not even register them. Not only that but we can also perceive 'apparent movement' in the images. This is due to an illusion called the phi phenomenon, which enables the mind to mentally bridge the gap between two still images.

The zoetrope can help us to achieve this psychological illusion by fooling the brain that what it's seeing is a continuous moving image. The toy features a hollow drum decorated inside with a



sequence of stationary images, each one different from the last. Around the edge of the drum, at regular intervals in between each image, are narrow slits through which the viewer can peer. The view through each slit reveals just one image at a time the one on the opposite side of the drum. When the drum is spun, however, the viewer sees multiple views through multiple slits, giving the impression of steady, continuous movement as the brain fills in the gaps between the pictures.



Prince

1 The first known description of a modern cuckoo clock comes from a 17th-Century German, who wrote of Prince Elector August von Sachsen owning one.

Black Forest

The clock's popularity grew during the 18th Century, with Germany's Black Forest at the heart of production. Today they can cost thousands of pounds.

Chalet

Through the 20th Century cuckoo clocks were commonly built in the shape of a wooden chalet, a style that originated in Switzerland, where they were sold as souvenirs.

Minimalist

Today, cuckoo clock design has become more varied both in form and function, with traditional and chalet, along with more modern, timepieces all available.

Totally cuckoo

5 The world's most extensive and finest collection of cuckoo Cuckooland Museum in Cheshire, England.

DIDYOUKNOW? The creation of the cuckoo clock is credited to Ancient Greek mathematician Ctesibius

Cuckoo clocks explained

How do these bird-ejecting timepieces work?



A cuckoo clock is a specialised type of pendulum-regulated (traditionally) timepiece that, as well as striking the hour like a

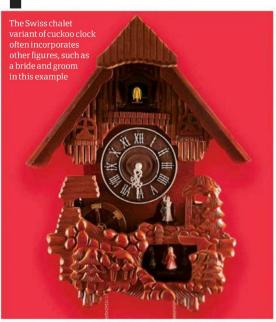
normal clock, releases a small model cuckoo and its audible call too. The clock works through a series of internal and external components that, together, eject the cuckoo and play its call in time with the faceplate's hands.

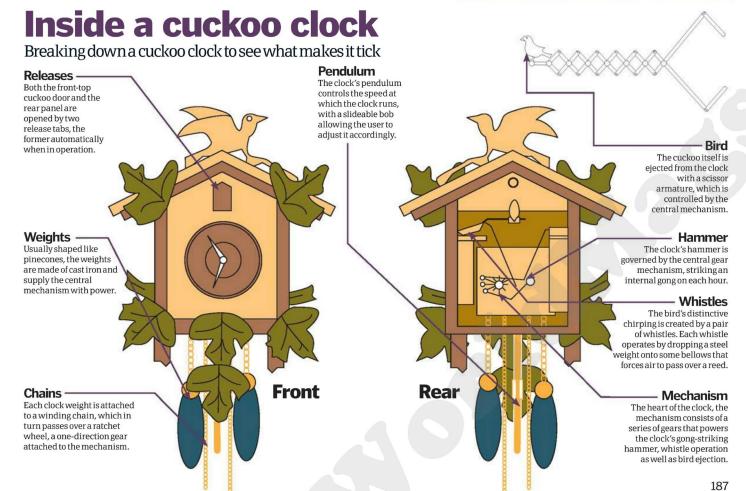
The cuckoo clock was invented in its 'modern' form during the 16th century in Germany, and since has diversified into three main types: Black Forest, Swiss chalet and modern quartz.

The first type is considered both the most traditional - it was in the Black Forest area that the first modern cuckoo clocks were created - and most valuable, as all cuckoo clock manufacture in the region is quality controlled. These clocks have full mechanical movements, requiring them to be frequently wound, and are driven by weights that hang down beneath the clock. These movements come in two distinct types: one-day and eight-day.

The second type is the chalet cuckoo clock. which was invented in the late-19th century in Switzerland. These clocks resemble wooden chalets and use either mechanical or quartz movements depending on their quality. A quartz movement differs markedly from a mechanical one in that it is powered by batteries rather than by winding and weights. The quartz movement works by using an electronic oscillator that is regulated by a quartz crystal to keep time, the oscillator creating a signal with a very precise frequency. Chalet cuckoo clocks also differ from Black Forest varieties in that they commonly have extra moving model features in addition to the traditional bird, such as woodcutter and housemaid figures.

The newest variant of cuckoo clock is the modern quartz. These tend to be more pared back in design and feature non-traditional internal mechanisms - for example, modern quartz cuckoo clocks produce their birdsong electronically via a digital recording, rather than the traditional dual bellows array.







Spinning jenny/Penicillin

Spinning jenny

A key development in the industrial revolution of England, the spinning jenny allowed yarn to be manufactured in large quantities



The spinning jenny - the world's first industrial spinning frame - worked by connecting multiple spindles

and multiple rovings (a long, narrow bundle of fibre) to the end of a fixed wooden frame. Onto these spindles numerous rove threads were affixed, extended down its length and clamped between two movable horizontal bars that when drawn towards the spinner extended the thread in straight lines. This motion was partnered with a twisting motion generated by turning a wheel attached to the frame, revolving the spindles and spinning the thread into yarn. Individual thread streams were separated by a vertical wire system

Spun thread was gently wound onto the

spindles ready for weaving

referred to as a faller, which dropped down between the lines and ensured they remained unconnected. At the culmination of the drawing out of the thread and the rotation of the wheel, the clasp bars returned to their original position and the yarn was deposited onto

the spindles. **Spindles**

Yarn spinning A fixed wooden or metal frame, upon which the other components and products

Faller (not shown)

Crucial for ensuring the finished yarn was correctly wound onto the spindle, the faller was a lowered pressing wire to separate thread streams.

Rovings

A set of long narrow bundles of fibres attached to a beam on the frame. The constituent threads were twisted by the jenny into yarn.

Cloves

Thread was drawn through the jenny's cloves, which were horizontal bars used to clasp the rove (thread) in place and draw out a portion for twisting.

Jenny who?

Hargreaves named the machine after his daughter. In fact, none of his daughters were named Jenny according to registers.

Smash and run

Fuelled by the jenny's ability to produce lots of yarn quicker and cheaper than traditional methods, the price of yarn fell dramatically in Hargreaves' local area, inciting the spinning community to ransack his house and smash his machines

Doubling up

The efficiency of the spinning jenny was an answer to high early-18th Century demand. whose productivity had doubled from the invention of the flying

Maximum spool

Hargreaves' original design of the spinning jenny allowed its operator to work eight spools at once. As the design evolved, the spools increased massively, often exceeding 100 to 120.

Spinning mule

early-19th Century by the spinning mule, a more advanced system that affixed the spindles to the carriage and a creel of roving bobbins on the frame.

Penicillin

How the discovery of penicillin helped re-define modern medicine

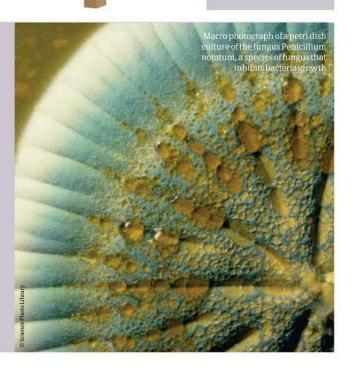


Although French student Ernest Duchesne noted the growth of penicillin in 1896, its true potential was not

realised until Scottish scientist Alexander Fleming re-discovered it in 1928. He noticed that colonies of the bacterium Staphylococcus aureus failed to grow in areas of a culture that had been contaminated by the green mold Penicillium notatum. However, its ability to kill infectious bacteria wasn't demonstrated until Dr Howard Florey's research at Oxford University over a decade later.

Penicillin, a group of antibiotics, works by inhibiting the bacterial

enzymes responsible for cell wall synthesis, while activating additional enzymes to break down the protective wall of the unwanted micro-organism. Consequently, penicillin is effective in combating micro-organisms that produce cell walls, as most bacteria constantly need to remodel their peptidoglycan cell walls as they grow and divide. This involves the pencillin's chemical structure binding to the enzyme that links the peptidoglycan molecules in the cell wall, inhibiting the formation of cell wall cross-links and causing the cell to burst (known as cytolysis) and cell death due to osmotic or water pressure.



5 TOP FACTS BEARD FACTS

Growing

The average human male grows 25,000 hairs on his face in the space of 24 hours. They will grow about half a millimetre in a day and 13mm in a month.

Genetic

2 Genetic factors determine the length, texture, colour and growth patterns of facial hair. Another factor that plays a part in hair growth is hormones.

Tug of war

Legendary King Alexander the Great ordered his soldiers to shave, as he feared that in battle the enemy could easily grab their beards and kill them.

Plucking

The great Roman ruler Julius Caesar had his facial hairs pulled out one by one by tweezers, rather than trust anyone to use a razor on his throat.

Wet and dry

When put under a microscope and examined, a wet razor shave looks much smoother than a dry shave carried out by an electric shaver.

DIDYOUKNOW? Gillette safety razors were given to US soldiers in WWI, so that gas masks would fit their clean-shaven faces

The first safety razor

Developing a safe and close shave



Jean-Jacques Perret is regarded as the inventor of the first safe razor that would not accidentally cause serious injury to your face. From

about 1600 until the 1900s, when the disposable safety razor was introduced, the most common shaving implement was the straight razor. It was capable of cutting a man's throat and was easily employed as a murder weapon or means of committing suicide. Not surprisingly, it was commonly called a 'cut throat' razor.

The straight razor consists of a blade that pivots on a pin attached to the top of a handle. This allows the blade to be folded – edge first – into the handle when it is not being used. It needed to be regularly sharpened and required a skilled hand to use it properly. For

those reasons, the local barber was the main place where men went for a shave, as barbers were specially trained to use a straight razor.

Perret was a master cutler who had a detailed knowledge of the science of steel making. Based in Paris, in 1769 he published a treatise called 'Pogonotomie, or The Art of Shaving Oneself' (Pogonotomie, au L'Art D'Apprende à se Raser Sol-Méme). This includes a description of a rasoir à rabot (razor with plane) that he invented in 1762 after seeing a carpenter's plane in action. Perret's idea was to sheath the blade of a straight razor with an L-shaped wooden sleeve, so that only the cutting edge of the blade was visible. This made it easier for more people to safely shave, and many European manufacturers subsequently copied his idea.



Gillette's disposable blade

King Camp Gillette was an American travelling salesman who found it time-consuming to sharpen his cut-throat razor on a leather strop. He thought it was wasteful to have a large and dangerous blade, when you could make a safe one to suit the size of a man's face. Alongside engineer William Emery Nickerson, Gillette produced a double-sided razor blade that fitted in a holder mounted on a handle. The blades were made of ultra-thin carbon steel and Gillette guaranteed they could be used for 20 shaves. Their cheapness and disposability meant that stropping was a thing of the past, and Gillette knew that he would make a fortune from selling the replacement packs of blades. His razor was patented in 1901 and went on sale in 1904.

Parts of the safety razor

This was the hardest

Gillette to produce. It

thin to work properly.

had to be literally paper

part of the razor for

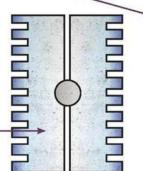
Handle

Originally silver- or gold-plated, the handle and blade support and blade guard were combined into one unit in models introduced in the Thirties.



Blade support

This screws onto the top of the handle and supports the blade, to give it enough rigidity for a close shave.





blade support, clamps the blade in position.

Blade guard

This is placed on top of the blade and, along with the

Evolution of the close shave

Prehistoric period

Prehistoric man used sharpened flint stones and even sharks' teeth to shave his hair. He also used two seashells as tweezers to pull out facial hair.

Ancient Egypt

In the Early Dynastic Period (3150-2686BC) ancient Egyptians used sharpened stones on handles for shaving. Later, bronze and copper razors were used by barbers to shave military men, the aristocracy and the public.

Cast steel

The straight razor was a development from earlier razors – it improved when constructed with crucible or cast steel. Benjamin Huntsman invented this steel in Sheffield in 1740.

Disposable razors

Since 1904, disposable razors have dominated the market. In 1974, the completely disposable plastic razor was introduced. Now, disposable razors or those with disposable shaver heads containing two or more blades are the norm.

The electric shaver

Jacob Schick patented a handheld electric shaver in 1923. With the development of smaller and more powerful electric motors in the late-Thirties, they found a growing market.



Thatching



Thatching explained

This traditional - and now very pricey - craft requires a host of speciality tools and techniques



Thatching is the craft of building a roof with a variety of dry vegetation, ranging from wheat and water reed through to long straw and heather.

The basic principle is to layer the thatch material in such a way that rainwater is shed away from the inner roof and off the side of the building, providing a waterproof barrier much the same as that granted by typical slate/tile-based roofs.

Any thatching operation starts with the preparation of the thatching material, with straws/reeds bundled together into a loose sheaf. The sheaf is then levelled off by first knocking it against the ground to force all strands to descend to the bottom, then secondly removing any remaining anomalies, and finally shearing off the bottom inch. This last step ensures that the sheaf has a neat, uniform finish. Once the sheaves (many are required) have been prepared, they can then be positioned on the roof.

The layering of the thatch begins at the bottom of the roof, where it is secured to the framework or a turf substrate (foundation) running over the framework - with wooden or metal rods called sways. Once this base is in place, layering of the thatch begins proper, with hazel rods, referred to as spars, used to peg sheaves into position up the roof. The positioning of the spars and layering of the thatch ultimately determines the quality of waterproofing and the roof's life span.

The type of thatching material varies in both price and longevity too, with straw roofs typically lasting between 20 and 30 years, and reed lasting 30-60 dependent on type. Long straw is cut in the field with a binder and then threshed in a drum,



Historically thatched roofs were associated with working-class housing, due to the abundance of wheat and free natural materials in rural areas. Today, however, thatched properties are typically far more expensive than slate-based equivalents due to the great drop in professional thatchers available, the limited quantities of cheap thatching materials and the higher-than"Hazel rods, referred to as spars, are used to peg sheaves into position"

A professional thatcher re-thatching a 16th-century cottage with wheat straw

Thatching step-by-step

overlapping maslin in place.

A look inside a 19th-Century Irish thatched cottage to see how its roof was built



How did the first electric battery work?

How the invention of the voltaic pile heralded a whole new era of electronic devices

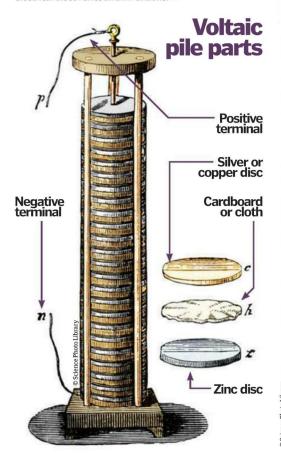


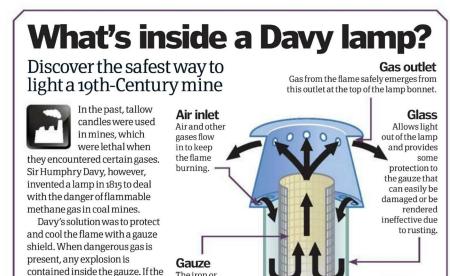
The Italian physicist Count Alessandro Giuseppe Volta invented the voltaic pile in 1800. It consisted of a series of cells layered in a vertical pile. Each cell was constructed of a disc

of silver or copper, a disc of card or cloth soaked in brine, and a disc of zinc. To gain a higher level of voltage more cells would be added to the pile.

The copper disc acts as the cathode, the brine is the electrolyte and the zinc disc acts as the anode. When copper wires are attached to the top and bottom of the pile of cells, it completes an electrical circuit, which causes a chemical reaction that releases electrons from the anode that are absorbed by the cathode. This produces a flow of 1.1 volts of electricity from each cell in the pile.

The voltaic pile was the first battery to produce a constant source of electricity that enabled and inspired many new electrical discoveries and inventions.





The iron or

copper mesh has

to be fine enough

enough to arrest

any ignition of

atmosphere. It

also cools and

retains the heat

radiating from

the lamp flame.

gases in the

to allow in air,

but dense

flame changes its shape or turns

blue, it indicates the presence of

potentially lethal gases, and if it

goes out or splutters, it indicates

the presence of carbon dioxide

Early versions of the lamp

explosions until the 1890s.

were fragile and not an adequate

or low levels of oxygen.

protection against mine



reservoir

The reservoir is

filled with oil or

naphtha (lighter

fluid) to fuel the

wick. It is often

magnetic lock to

fitted with a

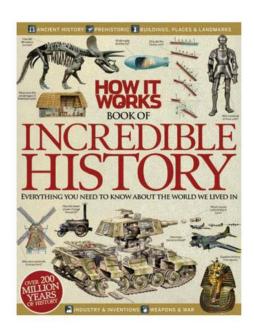
prevent

accidental

spillage.



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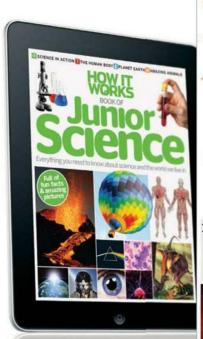
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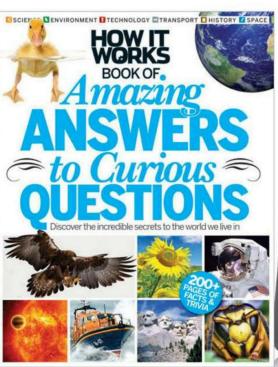
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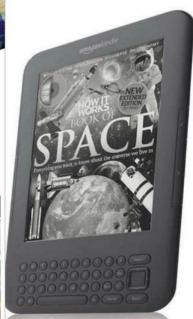
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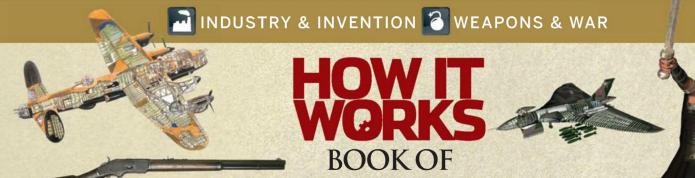
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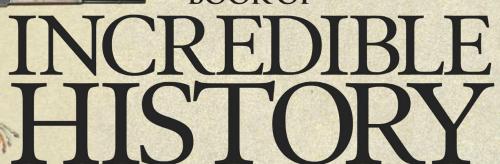


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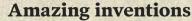






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